

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants : Giuseppe Calarco et al.
Application No. : 10/685,292
Filed : October 14, 2003
For : USER CONTROLLED DEVICE FOR SENDING CONTROL
SIGNALS TO AN ELECTRIC APPLIANCE, IN PARTICULAR
USER CONTROLLED POINTING DEVICE SUCH AS MOUSE
OR JOYSTICK, WITH 3D-MOTION DETECTION

Examiner : Regina Liang
Art Unit : 2629
Docket No. : 851663.482
Date : February 9, 2009

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPELLANT'S BRIEF

Commissioner for Patents:

This brief is in furtherance of the Notice of Appeal, filed in this case on October 6, 2008, and the Notice of Non-Compliant Appeal Brief, mailed January 11, 2009.

I. REAL PARTY IN INTEREST

The real party in interest is STMicroelectronics, which is the assignee of the present invention.

II. RELATED APPEALS AND INTERFERENCES

Appellants, Appellants' legal representative, and assignee are unaware of any appeals or interferences which directly affect or will be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 1-8, 10-14, 16-18, 20, 22, 30-39, 41-45, 48, 50-58, and 63-65 are pending, and claims 9, 15, 19, 21, 23-29, 40, 46, 47, 49, and 59-62 are cancelled. All pending claims are rejected, and the rejections of all of the pending claims are being appealed.

IV. STATUS OF AMENDMENTS

The Final Rejection was mailed May 6, 2008. A response to the Final Rejection was filed on August 6, 2008, without amendments. An advisory Action was mailed August 20, 2008, and a Notice of Appeal was filed on October 6, 2008. No amendments have been filed subsequent to the Final Rejection of May 6, 2008.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Portions of the specification were amended to correct a number of drafting errors. While the amendments are fully supported by the specification and drawings as originally filed, they nevertheless will complicate references to the specification over the course of this summary and the arguments that follow. Most of the errors were in a part of the specification that includes a description of steps for carrying out process steps according to some embodiments, which are correctly set forth in the detailed flow chart of Figure 11 as originally filed. Nevertheless, reference to those steps in the specification would require citations, variously, to the specification and to individual paragraphs in the amendments of October 4, 2006, and February 14, 2008. To simplify access to the specification as corrected, a clean copy of the specification is attached herewith in the evidence appendix, Section IX, as exhibit A. To avoid confusion with the claims appendix, the claims of the attached specification have been omitted. References to the specification will be to page and line numbers of the attached version, together with references to the drawings where appropriate. A concise correlation of each of the claims that will be separately argued and subject matter in the specification on which the respective claims read, with references by page and line number, is located at the end of this summary.

The summary that follows is intended to provide a general description of the subject matter on which the claims read. The scopes of the respective claims are not to be construed by this summary.

User controlled devices for directing a cursor on a computer screen are employed with virtually all general purpose computer systems and many specialized systems. Perhaps the most common of these is the computer mouse, which is provided with sensors to detect motion in two axes, and which produces a corresponding signal that is interpreted by hardware and software of the associated computer system in order to control movement of an on-screen pointer, and to activate various other functions. For a person who uses a computer mouse or other pointer control device, its operation falls into two distinct categories: on-screen pointer control, which is automatic and occurs any time the user moves the mouse; and function commands, which require that the user press buttons or move a scroll wheel, etc. to activate. Such function commands are so familiar to most computer-literate individuals that references to a “right click,” or “left click” are instantly understood as referring to the function commands that are normally executed by a computer when the user presses the right or left buttons of a standard mouse. Other common click functions include “click-and-hold,” “double click,” “drag-and-drop,” etc. Most such interface devices give the user the ability to designate specific operations for activation in response to various click functions. The disclosure likewise distinguishes between these two operations, *i.e.*, pointer control and activation of “click” functions (**6:18-21, 6:25-7:2**)¹. An embodiment of the invention provides a process whereby a user can direct movement of a cursor and also activate various click functions through movement of an input device, alone, without requiring buttons, wheels, etc. (**6:15-21, 8:5-8**).

An obvious application for such a process is incorporation into control devices used in the computer gaming industry, where such increased functionality provides additional options to the game designer, and a broader experience to the gamer (**1:6-8**; Figures 1-5). A less obvious, but perhaps more beneficial application is in giving individuals with limited mobility more direct access to computer operation and to the freedom that such access provides (**2:14-15**).

The inventors have envisioned an inertial sensor device, in one embodiment, that can be worn on a headband or eyeglasses by a person having little or no use of her hands (**6:6-8, 11:18-20**; 10, Figures 6, 7), and by movements of the head, she can control pointer movement

¹ For brevity, where specific passages of the specification are cited, they will be indicated, in bold text, by page and line numbers, separated by a colon, *e.g.*, **4:12**, which indicates page 4, line 12.

and function commands (6:15-21). Slow movements of the head are translated into on-screen pointer movement, while movements that exceed a selected speed threshold are translated into click commands (8:5-21). For example, a fast movement forward, as in a quick nod of the head, can be interpreted as a left click, a fast movement backward as a right click, and tilting movements to the right and left as other function commands, such as click-and-hold, scroll, etc.(8:18-25). In order to prevent unintended responses to normal small movements of the head, a movement must exceed a selected amplitude threshold to be recognized as a valid pointer movement command (8:8-11). With access to cursor movement control and basic function commands, even a severely disabled person can operate word processor and spreadsheet programs, surf the internet, send and receive email, and generally perform most computer operations that are a normal part of modern life for most people, but were previously difficult or impossible for the disabled individual.

A representative device and its operation will be described below in more detail. For the purpose of this discussion, a device that can be worn on a person's head will be described, as shown in Figure 6 of the specification, which is reproduced herebelow as Figure 1.

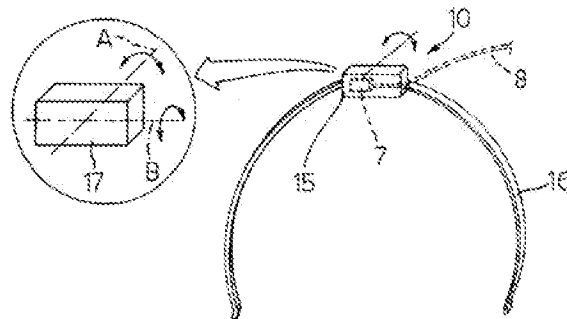


Figure 1
(Figure 6 of the Specification)

As described in the specification with reference to Figure 1, above, “a pointing device 10 includes a housing 15 fixedly attached to an article worn by the user. ...[T]he housing 15 is attached to a hairband 16 and accommodates the 3D-motion detection device 7, shown with dashed lines; the pointing device may be connected to the computer system through a wire 8 or, preferably, in a wireless way.”

“[T]ilting of the head of a user up-down and/or left-right causes tilting of the pointing device around axes A, B, as visible in the enlarged detail of Figure [1], and sending of corresponding signals to the computer system In addition, the pointing device 10 may be designed to associate specific movements of the housing 15 to “click” functions ...” (6:6-20).

One embodiment of the 3D-motion detection device 7 is shown diagrammatically in Figure 8, which is reproduced below as Figure 2.

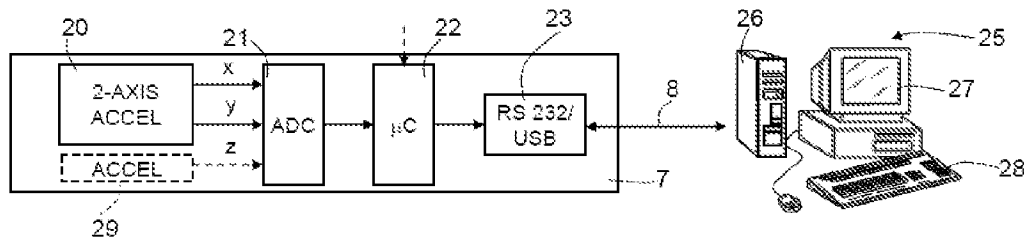


Figure 2
(Figure 8 of the Specification)

The 3D-motion detection device 7 includes a 2-axis MEMS-type accelerometer, such as is known in the art (6:24-25). “Accelerometer 20 generates two output signals X, Y *proportional to the tilting angle* of the ... pointing device 10 around axes A, B. Output signals X, Y are digitized in an analog-to-digital converter 21 and fed to a microcontroller 22” (6:23-28, *emphasis added*). It can be seen from this language that the X and Y signals are values that correspond to the instantaneous angle of rotation of the pointing device around axes A and B, respectively.

It should be noted that generally speaking accelerometers are sensitive to the force of gravity, which is detected as a negative acceleration downward, and it is because of this that they can be used to detect or measure the angular position of an object, relative to the earth’s center of gravity. This principle is well known in the art, and is employed, for example, in electronic levels that are used in the construction industry. In the case of the two-axis accelerometer 20, for example, the only position at which no acceleration due to gravity would be detected, and in which, therefore, the signals X and Y would indicate a zero tilt angle, would be while the device lies perfectly level and parallel to a horizontal plane.

The 3D-motion detection device 7 also includes a communication port 23, such as, for example, a USB-type port for signal exchange between the microcontroller 22 and a computer 25, which in the illustrated embodiment includes a central unit 26, a screen 27 and a keyboard 28 (7:3-6; Figure 8). Alternatively, a wireless connection can be employed for communication between the between the microcontroller and the computer (7:20-26; 31, 33, Figure 10).

An exemplary process by which the signals X and Y of the accelerometer 20 are used to provide on-screen pointer control and click functions is described with reference to the flow chart of Figure 11 of the specification. In Figure 11, steps 54 through 64 are directed to processing the signal X from the accelerometer 20, while steps 66 through 76 are directed to processing the signal Y, but in other respects steps 66 through 76 are substantial duplicates of Steps 54 through 64. A portion of the flow chart of Figure 11 is reproduced below as Figure 3. Steps 66 through 76 have been omitted from Figure 3 below, and some of the remaining steps have been repositioned to occupy less space on the page.

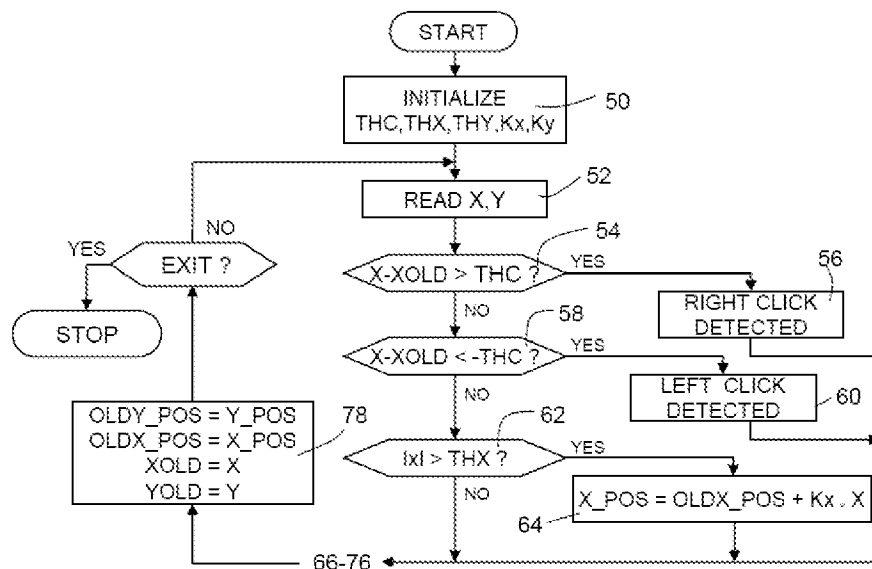


Figure 3
(From Figure 11 of the Specification)

During initialization of the 3D-motion detection device 7 (step 50), a clicking threshold (THC) is established, which represents the “minimum derivative” that will produce a

clicking function (9:3-5), and X and Y axis thresholds (THX, THY) are established, each of which represent the minimum signal that will be recognized as a valid pointer movement command in its respective axis (9:5-9). Additionally, X and Y multipliers (Kx, Ky) are established, that will be used to determine speed of movement of the on-screen pointer (9:9).

As noted above, the X and Y signals are proportional to the tilting angle in their respective axes, so a minimum signal threshold, *i.e.*, THX, THY, represents the smallest amplitude of angle, *i.e.*, the smallest deviation from a zero angle that the system will recognize as a command to move the on-screen pointer.

During the course of each iteration of the cycle described with reference to Figure 11 of the specification, a number of values are obtained and manipulated, as will be discussed in more detail shortly. These include values for X, Y, X_POS, and Y_POS. The values X and Y represent the angle at which the sensor device was positioned, relative to a horizontal plane, at the moment the signals from the accelerometer 20 were read, and the values X_POS and Y_POS represent the position of the pointer on the computer screen in the X and Y axes. At step 78, at the end of an iteration of the cycle and before a new iteration begins, the values for X, Y, X_POS, and Y_POS are saved, respectively, as XOLD, YOLD, OLDX_POS, and OLDY_POS (10:27-28). Thus, at the beginning of each new iteration, these old values from the most recently completed iteration are available for reference.

Turning now to the first steps of the repeating cycle, the device reads the signals X and Y from the sensors at step 52 (9:10-11), subtracts XOLD from the current value of X, then compares the resulting difference with the X threshold THC, at step 54 (9:11-15). If the difference derived from the subtraction is greater than THC, a right-click signal is produced at step 56 (9:15-19).

If $X - XOLD$ is not greater than THC, the same difference value is compared with a negative value of THC at step 58 (9:19-20), and if the difference is *lower*, *i.e.*, if the change is greater, in a negative direction, than the threshold value, a left click signal is produced, at step 60 (9:20-23).

In other words, in order to prompt a right- or left-click signal, the angle of rotation of the device 7 must be changed in either a positive or negative direction by a value that is

greater than the “minimum derivative” stored as THC, within the time period between step 52 of one repetition of the cycle and step 52 of the next repetition (**9:13-14**). So if, for example, the cycle frequency were ten cycles per second², and the threshold THC were a value corresponding to five degrees of rotation, the input device would need to be moved five degrees or more in less than one tenth of a second – the time between the beginning of one cycle and the beginning of the next at 10 Hz – in order to input a click command. Thus, in this example, the threshold THC can be represented as being equal to a change of value of 5° over a period of .1 seconds, or 50° per second: $THC = 50^\circ/s$. This is a rate-of-change equation, and thus, in the context of the present application, THC is a speed of movement threshold (**8:7-11** and **26-28, 9:15-19**).

Continuing now to step 62, if X-XOLD is lower than THC and higher than -THC, *i.e.*, if no right- or left-click command was detected, the absolute value of the signal X is compared with THX in step 62 (**10:24-28**), and if the absolute value of X is greater than THX, an on-screen pointer movement command is detected. The threshold THX serves to filter out small movements of the user’s head so the onscreen pointer doesn’t respond to every small shift or tremor (**10:26-28**). To determine how to move the pointer, in step 64, the value of X is multiplied by the value Kx, and the product is added to the value OLDX_POS, which, as noted above, represents the position of the pointer on the screen, in the X axis (**9:28-10:2**). Because X is proportionate to the angle of the device 7 worn by the user, the greater the rotation of the user’s head, the larger the value of X, and the further the pointer moves on the screen. Furthermore, because of the repeated cycling of the process, the pointer continues to move until the user returns her head to a neutral position. The result is a slow movement of the pointer if the angle is small, and a progressively faster movement as the angle increases. Thus, the user controls the speed of movement of the pointer by increasing or decreasing the angle.

At this point, it is of particular importance to recognize that if a click command is detected, the process skips the pointer movement detection step, which means that the process will move the pointer only if the user moves the device 7 at a speed below the threshold THC. Fast head movements produce a click command but no pointer movements, slow head

² Note that the refresh rate of a standard USB computer mouse is understood, typically, to be 125 Hz, so in actual practice, the cycle frequency would probably be set to a similar value, in order to emulate the signal of a conventional mouse (see **7:27-8:2**).

movements (of greater amplitude than the threshold THX) produce pointer movement, and the greater the degree of movement, the faster the pointer will move on the screen (**8:12-25**).

Following the steps discussed above, the process continues with steps 66-76, which, as previously noted, are substantially identical, except that the value of the signal Y is considered, instead of X (**10:6-23**). Accordingly, this portion of the process will not be discussed in detail.

Following steps 66-76, the values for XOLD, YOLD, OLDX_POS, and OLDY_POS are updated with the current values X, Y, X_POS, and Y_POS (**10:24-28**). The process continues to repeat until the device is switched off.

The preceding summary is provided as a general description of the disclosed subject matter, and does not limit or define the scope of the claims, which are to be construed by their own terms.

A. Correlation of Claims and Specification

Hereafter is a concise listing of the claims whose allowability will be argued directly, correlated with an example of subject matter on which each element reads, from the specification. For brevity, correlated subject matter is provided in connection with the first instance of each element with subsequent instances noted simply by reference characters. Text in the specification is referenced, in bold type, by column and line number, separated by a colon. This listing is provided for the purpose of simplifying review of the claims and subject matter. It is not to be construed as limiting the claims to the specific subject matter referenced, nor to the embodiments disclosed in the specification. Claims 10, 11, and 13 each include a means plus function limitations, and are reproduced here with the appropriate correlation to the corresponding structure in the specification and drawings, as required under 37 CFR § 41.37(c)(1)(v).

1. A user controlled device, comprising:

a body (7) (**6:6-10**; Figs. 6 and 8) that is movable into a plurality of positions of a three-dimensional space;

a MEMS acceleration sensor (20) (6:22-25; Fig. 8) coupled to the body (7) and configured to detect movements of said body (7) in first and second directions (6:25-27); and
a microcontroller (22) (6:27-28; Fig. 8) coupled to the MEMS acceleration sensor (2) and configured to generate first control signals (*corresponding signal*, 10:2; step 64 of Figure 11) correlated to said positions (9:29-10:2), only while detected movements of said body are less than a speed of movement threshold (9:24-25) and greater than an amplitude of movement threshold (9:28-29).

10. A device according to claim 1, further comprising transmission means (wire, 8, communications port 23) for connecting said microcontroller to an electrical appliance (5:3-6, 7:3-6; Figures 1, 8), said transmission means including a wire transmissive medium (8) and a communication port (23).

11. A device according to claim 1, further comprising transmission means (transmitter receiver 31, digital port 34) for connecting said microcontroller to an electrical appliance (3D-motion detection device 7) (5:3-6, 7:20-26; Figures 1, 10), said transmission means including an RF communication port (31, 33) for allowing wireless communication with said electrical appliance.

13. A device according to claim 1 wherein said microcontroller (22) comprises means (microcontroller 22, Fig. 6, by process of Fig. 11, steps 54, 56) for generating second control signals upon detecting movements of said device that are greater than said speed of movement threshold (9:11-19; Fig. 11).

16. A method for generating control signals correlated to positions of a user controlled device, comprising:

moving the user controlled device into one of a plurality of positions of a three-dimensional space (6:6-8, 6:15-16);

detecting movements of said device through a MEMS acceleration sensor (6:23-27);

deriving a rate of change of position (9:10-14; step 54, Fig. 11) and an amplitude of position (6:25-27) from the detected movements of said device;

comparing the rate of change with a speed threshold (9:14-15; step 54, Fig. 11);

sending function activation signals to an electrical appliance corresponding to an axis of movement of the device when the derived rate of change exceeds the speed threshold (9:15-19; step 54, Fig. 11);

comparing the amplitude of movement with an amplitude threshold (9:25-26; step 58, Fig. 11); and

sending pointer control signals to the electrical appliance corresponding to the axis and amplitude of position of the device (9:29-10:2; step 64, Fig. 11) only when the amplitude of position exceeds the amplitude threshold but the rate of change does not exceed the speed threshold (9:24-25; step 62, Fig. 11).

30. A method, comprising:

employing a MEMS sensor to detect movement of a body in a three-dimensional space (20, 6:22-25; Figs. 6, 8);

producing movement signals corresponding to the movement of the body (6:25-27; Fig. 8); and

producing control signals corresponding to the movement signals, and suitable for moving a pointer on a computer screen (8:5-6, 18-21; step 64 Fig. 11), provided the movement of the body does not exceed a speed threshold (8:12-17; steps 54, 58 (“NO” path), Fig. 11).

36. A system, comprising:

a computer screen (27) (7:5; Fig. 8);

a CPU coupled to the computer screen (27) (7:5; Fig. 8);

a pointing device coupled to the CPU (10) (7:5; Fig. 8);

a MEMS sensor (20), (Fig. 8) coupled to the pointing device (7), the MEMS sensor configured to produce position signals corresponding to movement of the pointing device (6:25-27); and

a microprocessor (22) coupled to the MEMS sensor (20), configured to compare a rate of movement of the pointing device to a threshold and, only if the rate of movement of the pointing device does not exceed the threshold, convert the position signals of the MEMS sensor to control signals suitable for controlling position of a pointer on the computer screen (9:24-10:2; steps 62, 64, Fig. 11).

38. The system of claim 36 wherein the microprocessor is configured to produce a function activation signal when the rate of movement of the pointing device exceeds the threshold (9:14-9:19).

42. A device comprising:

a body (10) (6:7; Fig. 6);

a sensor (20) coupled to the body (10) and configured to produce a first signal corresponding to rotation of the body (10) around a first axis (6:25-27); and

a circuit (22) configured to produce a cursor movement command in a first direction, corresponding to a value of the first signal, only when the first signal indicates rotation of the body that is lower than a speed threshold (8:18-20), and to produce a first function command when the first signal indicates rotation of the body that exceeds the speed threshold (8:12-14).

63. A device for user control of a computer system, comprising:

a body (10) (6:7; Fig. 6);

a sensor (20) coupled to the body (10) and configured to detect a position of the body in a three dimensional space and to produce a corresponding output signal (6:25-27); and

a circuit (23) configured to:

compare first X and Y output signals from the sensor with second X and Y output signals from the sensor and derive a change of position of the body from the first and second X and Y output signals (9:11-14, Step 54, and 10:7-9, step 66),

determine, from the change of position, a rate of change (9:11-14, 10:7-9),
compare the rate of change of position with a rate of change threshold, and
(9:11-14, 10:7-9),

only if the rate of change does not exceed the rate of change threshold,
produce a pointer control signal corresponding to a direction of movement of the body (9:24-10:2; steps 62, 64, Fig. 11).

64. The device of claim 63 wherein the circuit is configured to compare the amplitude of change with an amplitude threshold and produce the pointer control signal only if the amplitude of change exceeds the amplitude threshold (9:28-29).

VI. GROUND S OF REJECTION TO BE REVIEWED ON APPEAL

1. Whether claims 1, 13, 16, 30, 32, 36, 38, and 63 are unpatentable under 35 U.S.C. §103(a) over U.S. Patent No. 6,573,883 to Barlett, in view of “Two Dimensional Position Detection System with MEMS Accelerometer for Mouse Applications,” by Lee, et al.

2. Whether claims 42-45, 48, and 50-53 are unpatentable under 35 U.S.C. §103(a) over U.S. Patent No. 6,573,883 to Barlett, in view of U.S. Patent No. 6,765,553 to Odamura.

Claims 2-8, 10-12, and 54-56 stand or fall with claim 1. Claim 14 stands or falls with claim 13. Claims 17-18, 20, 22, 57, and 58 stand or fall with claim 16. Claims 31 and 33-35 stand or fall with claim 30. Claim 37 stands or falls with claim 36. Claims 39 and 41 stand or fall with claim 38. Claims 64 and 65 stand or fall with claim 63.

VII. ARGUMENT

In the arguments that follow, when a specific passage of a U.S. patent is cited, it will be indicated by a column number separated from a line number by a colon.

A. Introduction and discussion of the Bartlett reference

Appellants note that in the Final Office Action of May 6, 2008 (hereafter *Office Action*), each of the claim limitations argued below with respect to the independent claims 1, 16, 30, 36, and 63 are pointed to by Examiner Regina Liang (hereafter *Examiner*) as being taught by the Bartlett reference (Office Action, page 2, section 3). Furthermore, the Examiner does not argue that any of the other art of record teaches these particular limitations.

“To support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references.” *Ex parte Clapp*, 227 USPQ 972, 973 (Bd. Pat. App. & Inter. 1985). Accordingly, if Bartlett fails to teach or suggest any of these limitations, or if one of ordinary skill would not have found them obvious in its light, the respective claims are allowable over the remaining art.

The Bartlett reference is directed to a handheld computing device having sensors configured to sense position and orientation of the device (Bartlett, 1:53-62), and a method is provided for inputting data commands. Commands are separated into position commands and gesture commands (*id.*, 3:13). Position commands are correlated to a particular angular orientation of the device at any given instant in time, and are submitted instantaneously simply by virtue of holding the device at an angle (*id.*, 3:24-29, 39-42), while gesture commands require an interval of time for submission, and comprise unique patterns of movement over that interval of time (*id.*, 3:29-34, 42-46).

Position commands can be used, for example, to scroll through menus or data (*id.*, 5:22-47). Increasing or decreasing the angle of the device causes the scrolling rate to increase or decrease, etc. (*id.*, 5:42-47).

Gesture commands, in contrast, are series or patterns of motions performed by a user over an interval of time, during which time the device measures the motions, and, at the end of the interval of time, determines whether a gesture command was executed (*id.*, 3:31-34, 43:47-52). An example of a gesture command is shown graphically in Bartlett’s Figure 2a, which is provided below as Figure 4.

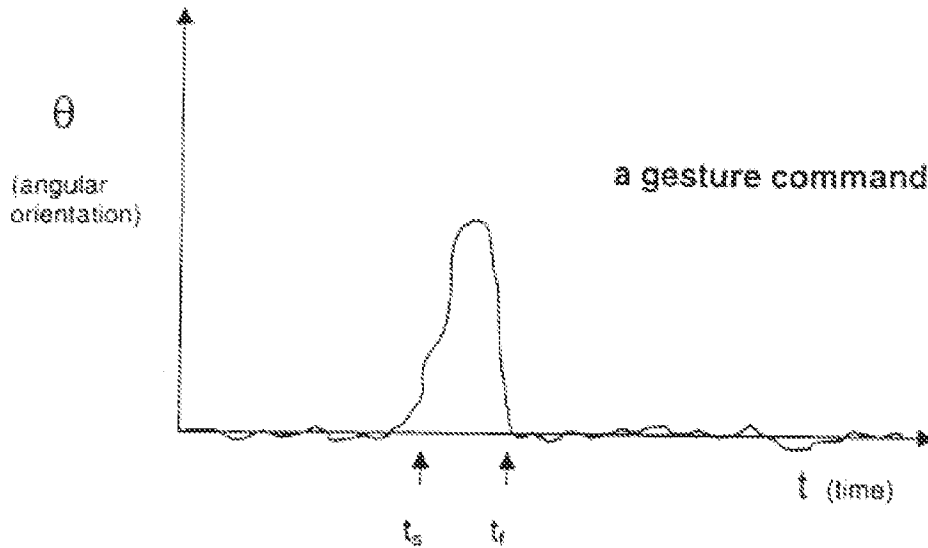


Figure 4
(Figure 2a of Bartlett)

Figure 4 shows “a gesture command that comprises a rotation in a positive angular direction followed immediately by a return approximately to the starting position” (*id.*, 4:18-21). The gesture begins at time t_s and ends a time t_f , at which point the computing device compares the series of motions with a catalog of gestures to determine whether if the series matches a gesture in the catalog (*id.*, 4:53-60), making allowance for minor variations that will be inevitable for movements made by hand (*id.*, 4:60-63, see also flow chart, Fig. 3). If a match is found, the corresponding command is executed.

Bartlett’s method cannot identify a gesture command until the end of the time interval, during which a series of motions are executed that are initially interpreted as position commands. This could create potential confusion (*id.*, 6:49-58), so Bartlett provides a procedure for resolving the question, described with reference to the flow chart of Figure 6, which is provided below as Figure 5.

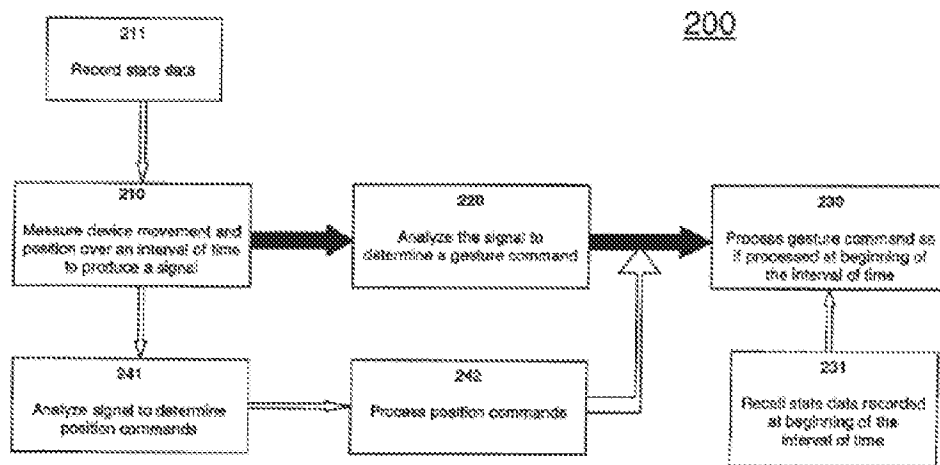


Figure 5
(Figure 6 of Bartlett)

At step 211, the device records the state of the device, *e.g.*, the menu item or icon that is highlighted (*Id.*, 7:21-22). The series of motions is measured over the time interval, at step 210 (*Id.*, 6:65-67), and compared with the catalog to determine whether a gesture command was entered, at step 220 (*Id.*, 6:67-7:2). Meanwhile, the motions are analyzed as position commands and executed, at steps 241, 242 (*Id.*, 7:6-14). If a gesture command is detected at step 220, the corresponding action is executed as though it had occurred at time t_s , at step 230 (*Id.*, 7:3-5). This is accomplished by retrieving the state of the device, which was previously recorded at time t_s , at step 211 (*Id.*, 7:22-27).

In other words, a user can, for example, scroll to a particular menu item using position commands, then, by moving the device in a series of motions, activate the highlighted item using a gesture command. As the user is moving the device in the correct series of movements of the intended gesture command, the device will respond to the motions of the gesture as though they are individual position commands, by scrolling away from the selected item, or whatever other actions are indicated, but, upon determining that a gesture command was executed, the device will return to the point in time where the command began, in order to determine which menu item was highlighted, then respond to the gesture command by activating the menu item (*Id.*, 7:28-38).

Appellants wish to call particular attention to a couple of features of Bartlett's method that will have particular relevance to the arguments that follow. First, all motions,

regardless of whether they are intended as a position command or as part of a gesture command will be executed as a position command; in the case where a gesture command is later detected, the erroneously executed position commands are reversed, but that is not the same as not having executed them in the first place. Second, Bartlett places no restrictions on its motion or gesture commands with regard to speed of movement. Certainly, individual gesture commands would require that the gesture user perform the gesture at about the same speed as was originally programmed, but there is no suggestion that all commands must be executed at a same rate, so one of ordinary skill would understand that each gesture could be programmed for a different speed.

B. Rejection under 35 USC §103(a) over U.S. Patent No. 6,573,883 to Bartlett, in view of “Two Dimensional Position Detection System with MEMS Accelerometer for Mouse Applications,” by Lee, et al. (hereafter Lee).

1. Claims 1, 2-8, 10-12, 54-56

Claim 1 recites, in part, “a microcontroller ... configured to generate first control signals correlated to said positions, only while detected movements of said body are less than a speed of movement threshold ...” (emphasis added). Bartlett fails to teach or suggest this limitation. In rejecting claim 1, the Examiner points to Bartlett’s position commands as corresponding to the first control signals, stating that Bartlett’s device produces the position commands correlated to the positions “only while detected movements of the body are less than a speed of movement threshold,” and supports the position by arguing that “no *gesture command* is detected [while detected movements of the body are less than a speed of movement threshold]; note that the *gesture command* as shown in Figs. 2a-2d correspond to a speed threshold, *e.g.*, in Fig. 2a, the quick movement of the handheld has to be greater than the angular orientation about an axis of rotation during the time interval between t_f - t_s , an activation signal is detected, otherwise, the activation signal is not detected, thus, the angular orientation about an axis of rotation during the time interval reads on a speed of movement threshold or speed threshold as claimed ...” (Office Action, page 2, last paragraph to page 3, lines 1-2, emphasis added.) Appellants strongly disagree. The Examiner points to Bartlett’s position commands as corresponding to the first control signals recited in the claim, but the supporting argument is

directed to gesture commands, about which the claim is silent. Whether the gesture commands correspond to a speed threshold is of no relevance. Furthermore, Bartlett does not teach a speed threshold, even for the gesture commands, so the argument is incorrect on that basis, as well.

In response to a similar argument presented previously, the Examiner states that *Bartlett's device generates the position command signal only when no gesture command is detected* Bartlett teaches if any of gesture commands are detected ... the device of Bartlett would generate an activation signal to activate a gesture commands, otherwise, no gesture command is generated [*sic*], therefore, Bartlett does consider speed of movement....” (*Id.*, page 13, lines 1-2, emphasis added.)

Appellants understand the Examiner's reasoning, as set forth in the rejection and the response to Appellants' argument, to be that (1) Bartlett's position commands are generated only when no gesture command is detected; (2) Bartlett's gesture commands are detected only when movement exceeds a speed threshold; and therefore, (3) Bartlett's position commands are generated only when movement is less than the speed threshold. Appellants believe that all three points are incorrect.

First, contrary to the Examiner's statement, Bartlett specifically teaches that position commands are generated even when gesture commands are detected. Bartlett states that “[c]omplete submission of the gesture command, however, requires a finite interval of time Δt equal to t_f minus t_s . Therefore, the existence and identity of the command cannot be determined until an interval of time of length Δt after submission of the command begins. Confusion in command processing can occur during the interval of time. For example, *the various elements of a gesture command can be interpreted to be a series of position commands and acted upon as such* prior to completion of the gesture command” (Bartlett, 6:49-58, emphasis added). As noted previously, reversing the effects of an executed command is not the same as not having executed the command in the first place.

Second, Bartlett does not teach a speed of movement threshold below which it will not detect a gesture command. Only four examples are provided (*Id.*, Figures 2a-2d), and they are not depicted with a scale to show how long the period Δt is, nor whether it is slow or fast. Furthermore, they are shown with random lengths on the pages, even though it is inherent

that the interval must always be the same so that the device can determine what motions should be considered when comparing with the catalog. Bartlett states that “the particular gesture command that was submitted is determined in step 121 [of Figure 3]. This determination is accomplished by comparison of the gesture that was submitted *during the interval of time* with a catalog of gesture commands” (*Id.*, 4:54-58, emphasis added). Bartlett teaches that “a series of position commands can be submitted along with a series of gesture commands” (*Id.*, 5:1-2). It is quite clear that Bartlett’s device can’t differentiate between position and gesture commands until it searches the catalog (*Id.*, 6:54-58), so it has no way of determining when a gesture command begins except by looking back at all the position commands submitted within a specific period of time. It can be seen then that the interval of time must be known before the particular gesture is detected. Otherwise, it would have been impossible to determine which motions were submitted during the interval. Thus, the intervals are all the same length. It is also therefore inherent that a gesture that includes more movements, like that of Figure 2b, for example, may require movements that are faster than one with fewer movements, like that of Figure 2a, in order to be executable within the same interval of time. Clearly, Bartlett does not restrict the gesture commands to some arbitrary speed threshold.

Finally, There is no teaching that Bartlett’s position commands must be slower than its gesture commands, even if Appellants were to concede the first two points. Reproduced below as Figure 6 is Bartlett’s Figure 2a again. The horizontal axis indicates time and the vertical axis indicates angular orientation of the device. Thus, a line on the graph indicates a rate of change of angle of the device, or speed of movement, as indicated by the slope of the line. A dotted line T has been added in Figure 6 to show the approximate rising slope of the line on the graph, thus indicating Bartlett’s threshold for the gesture command in the example given, and a shaded area is provided to encompass the range of movement that exceeds the threshold.

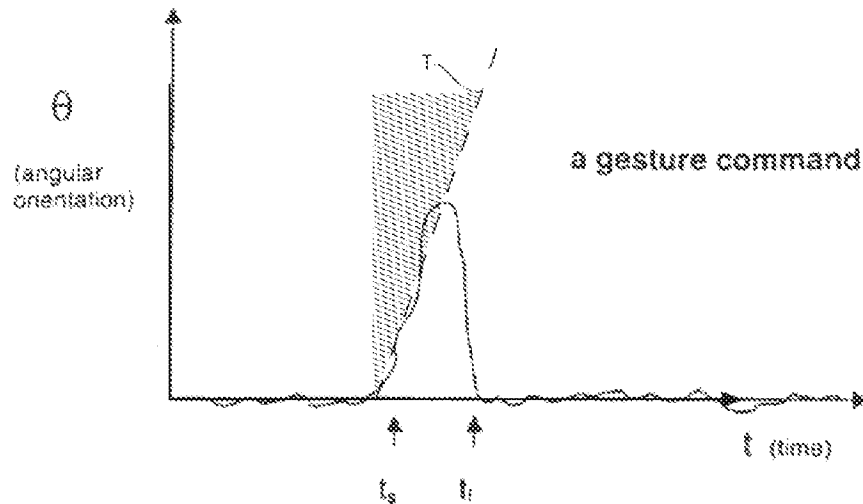


Figure 6
(From Bartlett's Figure 2a)

The microcontroller of claim 1 generates the first control signals *only* while detected movements are less than a speed of movement threshold. Therefore, *no movement* whose plotted line enters the shaded area can result in the generation of a first control signal. Thus, if Bartlett's process produces any position commands in response to a movement whose line would enter the shaded area, then it fails to teach or suggest the quoted limitation of claim 1. Figures 7-9 each show a graph on which the threshold line T is provided, as well as a line B corresponding to Bartlett's gesture command described with reference to its Figure 2a.

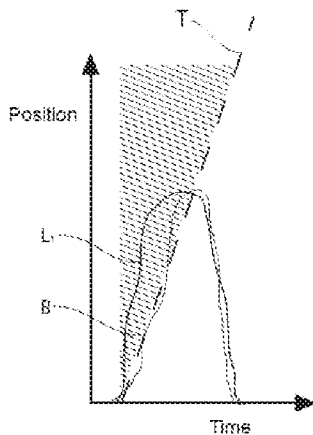


Figure 7

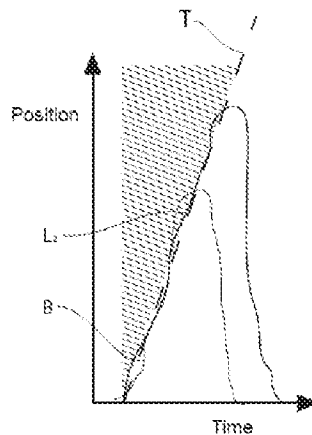


Figure 8

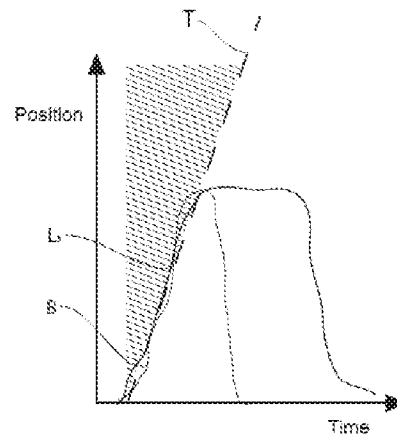


Figure 9

Referring to Figure 7, a line L_1 is provided, depicting a movement that is much faster than the threshold T . Assuming that the difference in the slopes of lines L_1 and T exceeds

the allowance made for minor variations (*Id.*, 4:60-63), the movement of line L₁ would not be recognized as a gesture command, and would therefore result in corresponding position commands (*Id.*, 7:8-9), even though the movement clearly exceeds the threshold.

Figure 8 shows a line L₂ that rises at approximately the same rate as line T, but rises much further than the gesture command indicated by line B. Again assuming that the difference in height is greater than the minor variation allowance, Bartlett would again fail to recognize the movement as a gesture command and would therefore produce position commands in response.

Finally, with reference to Figure 9, line L₃ rises at approximately the same rate as line T, but remains at the new position longer than line B, and would therefore again fail to be recognized as a gesture command.

In each of the three examples provided above, movements are shown that meet or exceed the Examiner's speed of movement threshold and yet, according to Bartlett's disclosure, would still result in its device producing a position command. Thus, Bartlett clearly does not teach producing such a command only while detected movements are less than a speed of movement threshold, but also produces such commands while detected movements exceed the threshold. Bartlett cannot therefore teach or suggest that limitation of claim 1.

For the reasons set forth above, claim 1 is allowable over Bartlett, together with dependent claims 2-8, 10-12, and 54-56.

2. Claims 13 and 14

Claim 13 recites that "said microcontroller comprises means for generating second control signals upon detecting movements of said device that are greater than said speed of movement threshold." The Examiner points to Bartlett's gesture commands as corresponding to the second control signals of claim 13. Appellants respectfully disagree. As discussed in more detail above, Bartlett does not impose a speed threshold on its gesture commands, but even more importantly, Bartlett does not teach generating gesture commands upon detecting movements that are greater than a speed of movement threshold, but instead detects gesture commands upon finding a gesture command in its catalog whose characteristics match the motions performed by the user, including speed, amplitude and timing of individual movements.

As has been demonstrated, Bartlett responds to movement in general as though all movements were position commands. Therefore, claim 13 is allowable over Bartlett, together with claim 14.

3. Claims 16-18, 20, 22, 57, and 58

Claim 16 recites, in part, “sending function activation signals to an electrical appliance corresponding to an axis of movement of the device when the derived rate of change exceeds the speed threshold; [and] sending pointer control signals to the electrical appliance corresponding to the axis and amplitude of position of the device only when ... the rate of change does not exceed the speed threshold.” (Emphasis added.) Claim 16 is allowable for many of the same reasons that were submitted in support of the allowability of claims 1 and 13 over Bartlett. In particular, Bartlett fails to teach or suggest sending function activation signals when the derived rate of change exceeds the speed threshold, teaching instead sending gesture command signals whenever a series of motions executed within an interval of time matches a gesture command stored in a catalog. Bartlett also fails to teach or suggest sending pointer control signals only when the rate of change does not exceed the speed threshold, teaching, instead, sending a position command signal anytime a movement of sufficient amplitude is executed, regardless of the speed of the movement, and, if a gesture command is later detected, reversing the effect of the position command. Dependent claims 17, 18, 20, 22, 57, and 58 are also allowable as depending from an allowable base claim.

4. Claims 30, 31, and 33-35

Claim 30 recites, in part, “producing control signals corresponding to the movement signals, and suitable for moving a pointer on a computer screen, provided the movement of the body does not exceed a speed threshold.” (Emphasis added.) Bartlett does not teach this limitation. Bartlett teaches generating position commands without regard to a speed threshold, but reversing them if a gesture command is detected. Even if there were some minimum speed at which Bartlett’s gesture commands were required to be executed, this would not be a threshold for its position commands, otherwise there would be no need to correct for “false position commands” (*id.*, 7:10-15), inasmuch as there would be no question about whether a particular movement was part of a gesture command or a position command. Bartlett cannot teach or suggest this limitation of claim 30, which is therefore allowable.

5. Claim 32

Claim 32 recites “producing function activation signals corresponding to movement of the body that exceeds the speed threshold.” As previously demonstrated, Bartlett generates gesture commands that match gesture commands stored in its catalog. Bartlett is entirely silent with regard to a particular minimum speed, and it is clear from its examples, *e.g.*, Figures 2a and 2b, that it does not intend that all movements be of a same speed, or faster than some threshold. Accordingly, claim 32 is allowable over Bartlett.

6. Claims 36 and 37

Claim 36 recites, in part, “a microprocessor ... configured to compare a rate of movement of the pointing device to a threshold and, only if the rate of movement of the pointing device does not exceed the threshold, convert the position signals ... to control signals suitable for controlling position of a pointer on the computer screen.” (Emphasis added.) .) Bartlett fails to teach or suggest this limitation. As discussed in more detail above, Bartlett does not teach a rate of movement threshold, but instead processes all movements as position commands, then reverses the effects of commands that turned out to be erroneous. Claim 36 is therefore allowable over the art of record, together with dependent claim 37.

7. Claims 38, 39, and 41

Claim 38 recites that the microprocessor of claim 36 “is configured to produce a function activation signal when the rate of movement of the pointing device exceeds the threshold.” As demonstrated, Bartlett does not produce its gesture command in response to a rate of movement, but in response to a detected match, and therefore fails to teach or suggest the limitations of claim 38, which is therefore allowable. Claims 39 and 41, which depend from claim 38, are also therefore allowable.

8. Claims 63-65

Claim 63 recites, in part, “a circuit configured to ... [produce a pointer control signal] only if the rate of change does not exceed the rate of change threshold ...” (Emphasis added.) Bartlett fails to teach or suggest this limitation of claim 63, which is therefore allowable over the art of record, together with dependent claims 64 and 65.

9. Advantage of the claimed inventions over the Bartlett reference

The claimed methods and structures of the present application provide some significant advantages over Bartlett's process. First, the likelihood of confusion is greatly reduced. For example, the Appellants' process first determines whether a click command has been entered, then determines whether a cursor movement command exists, and therefore does not execute a cursor movement command unless the criteria for a click command are not met. In contrast, Bartlett executes all position commands and then compares the associated movements with its catalog to determine whether they were in fact intended as a gesture command, in which case it reverses the erroneously executed position commands. If a user is attempting to enter a gesture command into Bartlett's device, she may observe the execution of perceived position commands on the screen of the device – as it scrolls away from her intended file, for example, and believe that she has made a mistake. If she then falters during the gesture command, or otherwise fails to properly complete the command, this will break the correct series of movements, resulting in a failure of the device to detect the command, which in turn will prevent the reversal of the previously executed position commands. Thus, before the user can reattempt a failed gesture command, she must first manually reverse each unintended position command. This creates a process that is much more complex and difficult for the user, and fraught with the possibility of error.

Second, Bartlett's device must continually record and hold in its memory every change of state for a period long enough to detect a gesture command (7:22). In contrast, the process of Figure 11 requires only that the most recent values of X and Y (XOLD, YOLD), and the most recent cursor positions (OLDX_POS, OLDY_POS) need be held in memory. This means that much more of Bartlett's RAM memory must be dedicated to holding those changes for a period at least as long as the time interval.

Third, the processing requirements for Bartlett's process are significantly greater than those of the Appellants' process, requiring a comparison of every series of movements with a catalog of gesture commands (4:55-60), each of which may include a large number of complex elements. This is in contrast to the process of Figure 11, which merely requires a few simple arithmetic procedures and comparisons with thresholds to determine how to interpret an action.

Fourth, operation of a device according to an embodiment of the present invention can be must faster than with Bartlett. Assuming that the same actions associated with various of Bartlett's gesture commands are associated with respective ones of the click commands of the described process, each click command and each cursor movement command can be executed instantly, while Bartlett's gesture commands each require an extended and fixed time period, even if the actual motion of the gesture command is simple and brief. Accordingly, the user must wait the full length of the time period before proceeding to a next position or gesture command.

Appellants note that the omission of an element and retention of its function is an indicia of unobviousness (In re *Edge*, 359 F.2d 896, 149 USPQ 556 (CCPA 1966)). While Appellants believe that the claimed inventions are not analogous to the system and method disclosed in Bartlett. However, if it is considered that the functions of the claimed inventions are analogous to those of the Bartlett reference, there are a number of elements that have been omitted while retaining that function. These include the catalog as well as the process step of comparing the inputted command with the catalog; the process step of continually recording the changes of state; the process step of waiting to the end of a time interval to determine whether a gesture command has been inputted, etc. It is clear that the differences that distinguish the processes are not insignificant.

10. Dependent claims rejected over additional references and not argued

Claims 2-8, 10-12, 14, 17-18, 20, 22, 31, 33-35, 37, 39, 41, 54-58, 64, and 65 were each rejected over Bartlett in view of one or more of Lee, Svancarek, Kuga, Davison, and Odamura. In no case does the Examiner suggest that any of these references except Bartlett teaches or suggests the limitations argued above, nor do the Appellants believe that such is the case. These claims are therefore listed with a respective parent claim or claim, and are allowable therewith.

C. Rejection under 35 U.S.C. §103(a) over U.S. Patent No. 6,573,883 to Bartlett, in view of U.S. Patent No. 6,765,553 to Odamura.

1. Claims 42-45, 48, and 50-53

Claim 42 recites, in part, “a circuit configured to produce a cursor movement command in a first direction, corresponding to a value of the first signal, only when the first signal indicates rotation of the body that is lower than a speed threshold, and to produce a first function command when the first signal indicates rotation of the body that exceeds the speed threshold.” (Emphasis added.) Bartlett fails to teach or suggest this limitation of claim 42. The Examiner points to Bartlett’s position commands as corresponding to the cursor movement commands of claim 42, Bartlett’s gesture commands as being analogous to the function commands, and states that “the quick movement of the handheld [as shown in Figure 2a] has to be greater than the angular orientation about an axis of rotation during the time interval between T_f - T_s , an activation signal is detected, otherwise the activation signal is not detected, thus, the angular orientation about an axis of rotation during the time interval reads on a speed threshold as claimed” (Office Action, page 9, second paragraph). Appellants disagree for all the reasons set forth in support of the allowability of claims 1 and 13. In view of those comments, Appellants believe that claim 42 is allowable over Bartlett. The Odamura reference cannot provide the missing teachings. Accordingly because Bartlett fails , which is therefore allowable over the art of record. Claim 42 is therefore allowable over the art of record, together with dependent claims 43-45 and 50-52.

D. Conclusion.

In summary, Appellants submit that claims 1, 13, 16, 30, 32, 36, 38, 42, and 63 are patentable over the art of record because the prior art references do not teach or suggest, either individually or in combination, all of the limitations of the respective claims. The Bartlett reference does not teach any speed thresholds or limits on either its gesture commands or its position commands, and therefore cannot meet essential limitations in all of the claims. The remaining references cannot remedy the deficiency of Bartlett. The Examiner has not supported a *prima facie* case of obviousness, because the limitations discussed with reference to the claims listed above are not found in any of the references. Appellants therefore respectfully request a speedy and favorable decision.

Respectfully submitted,
SEED Intellectual Property Law Group PLLC

/Harold H. Bennett II/
Harold H. Bennett II
Registration No. 52,404

HHB:lch

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

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VIII. CLAIMS APPENDIX

1. A user controlled device, comprising:
a body that is movable into a plurality of positions of a three-dimensional space;
a MEMS acceleration sensor coupled to the body and configured to detect movements of said body in first and second directions; and
a microcontroller coupled to the MEMS acceleration sensor and configured to generate first control signals correlated to said positions, only while detected movements of said body are less than a speed of movement threshold and greater than an amplitude of movement threshold.
2. A device according to claim 1 wherein said body is in a form selected between computer mouse, joystick, gamepad, and PDA.
3. A device according to claim 1 wherein said body is supported so as to be tiltable around two axes.
4. A device according to claim 3 wherein said body 2 is mouse-shaped and is supported by one of the following: rounded base, at least one spring, yieldable balls, or elastically supported balls.
5. A device according to claim 1 wherein the body is a housing accommodating said MEMS acceleration sensor and fixed to an article to be worn by the user.
6. A device according to claim 5 wherein said article is configured to be borne by the user's head.
7. A device according to claim 6 wherein said article is selected between a hairband and eyeglasses.

8. A device according to claim 1 wherein said MEMS acceleration sensor comprises at least a two-axis accelerometer or two one-axis accelerometers.

9. (Cancelled)

10. A device according to claim 1, further comprising transmission means for connecting said microcontroller to an electrical appliance, said transmission means including a wire transmissive medium and a communication port.

11. A device according to claim 1, further comprising transmission means for connecting said microcontroller to an electrical appliance, said transmission means including an RF communication port for allowing wireless communication with said electrical appliance.

12. A device according to claim 1 wherein said first control signals comprise a control signal for displacing a screen pointer along a first direction upon detection of movement of said device in said first direction and a control signal for displacing said screen pointer along a second direction upon detection of movement of said device in said second direction.

13. A device according to claim 1 wherein said microcontroller comprises means for generating second control signals upon detecting movements of said device that are greater than said speed of movement threshold.

14. A device according to claim 13 wherein said second control signals comprise control signals for activating functions that include clicking; continuous clicking; and continuous clicking release functions.

15. (Cancelled)

16. A method for generating control signals correlated to positions of a user controlled device, comprising:

- moving the user controlled device into one of a plurality of positions of a three-dimensional space;
- detecting movements of said device through a MEMS acceleration sensor;
- deriving a rate of change of position and an amplitude of position from the detected movements of said device;
- comparing the rate of change with a speed threshold;
- sending function activation signals to an electrical appliance corresponding to an axis of movement of the device when the derived rate of change exceeds the speed threshold;
- comparing the amplitude of movement with an amplitude threshold; and
- sending pointer control signals to the electrical appliance corresponding to the axis and amplitude of position of the device only when the amplitude of position exceeds the amplitude threshold but the rate of change does not exceed the speed threshold.

17. A method according to claim 16 wherein the detecting step comprises detecting tilting movements of a body accommodating said MEMS acceleration sensor around two axes.

18. A method according to claim 16 comprising generating position signals corresponding to movements of said device along respective directions, and wherein said position signals are processed to generate said control signals.

19. (Cancelled)

20. A method according to claim 18 wherein said control signals comprise displacing signals for displacing a screen pointer along two directions.

21. (Cancelled)

22. A method according claim 18 wherein said function activation signals comprise clicking, continuous clicking, and continuous clicking release functions.

23-29. (Cancelled)

30. A method, comprising:
employing a MEMS sensor to detect movement of a body in a three-dimensional space;
producing movement signals corresponding to the movement of the body; and
producing control signals corresponding to the movement signals, and suitable for moving a pointer on a computer screen, provided the movement of the body does not exceed a speed threshold.

31. The method of claim 30 wherein the producing control signals step includes ignoring movement signals that do not exceed an amplitude threshold.

32. The method of claim 30, further comprising producing function activation signals corresponding to movement of the body that exceeds the speed threshold.

33. The method of claim 30 wherein the movement signals include a first movement signal corresponding to a movement of the body in a first direction and a second movement signal corresponding to a movement of the body in a second direction, and wherein the control signals include a first control signal corresponding to the first movement signal and a second control signal corresponding to a second control signal.

34. The method of claim 33 wherein the first control signal is suitable for moving the pointer in a first pointer direction and the second control signal is suitable for moving the pointer in a second pointer direction.

35. The method of claim 30, further comprising:
coupling the body to a user's head; and
moving the body by moving the user's head.

36. A system, comprising:
a computer screen;
a CPU coupled to the computer screen;
a pointing device coupled to the CPU;
a MEMS sensor coupled to the pointing device, the MEMS sensor configured to produce position signals corresponding to movement of the pointing device; and
a microprocessor coupled to the MEMS sensor, configured to compare a rate of movement of the pointing device to a threshold and, only if the rate of movement of the pointing device does not exceed the threshold, convert the position signals of the MEMS sensor to control signals suitable for controlling position of a pointer on the computer screen.

37. The system of claim 36 wherein the MEMS sensor is configured to produce position signals corresponding to movement of the pointing device around first and second mutually perpendicular axes.

38. The system of claim 36 wherein the microprocessor is configured to produce a function activation signal when the rate of movement of the pointing device exceeds the threshold.

39. The system of claim 38 wherein the function activation signal is a click signal.

40. (Cancelled)

41. The system of claim 38 wherein the microprocessor is further configured to control a speed of movement of the pointer in accordance with a movement amplitude of the pointing device.

42. A device comprising:
a body;
a sensor coupled to the body and configured to produce a first signal corresponding to rotation of the body around a first axis; and
a circuit configured to produce a cursor movement command in a first direction, corresponding to a value of the first signal, only when the first signal indicates rotation of the body that is lower than a speed threshold, and to produce a first function command when the first signal indicates rotation of the body that exceeds the speed threshold.

43. The device of claim 42 wherein the first function command is a mouse click command.

44. The device of claim 42 wherein the circuit is configured to produce the first function command when the first signal indicates rotation of the body in a first direction exceeding the speed threshold, and to produce a second function command when the first signal indicates rotation of the body in a second direction exceeding the speed threshold.

45. The device of claim 44 wherein the first function command is a left mouse click command and the second function command is a right mouse click command.

46. (Cancelled)

47. (Cancelled)

48. The device of claim 42 wherein the circuit is configured to produce the cursor movement command only when the first signal indicates rotation of the body exceeding an amplitude threshold.

49. (Cancelled)

50. The device of claim 48 wherein the speed and amplitude thresholds are selectable by a user of the device.

51. The device of claim 42 wherein the sensor is further configured to produce a second signal corresponding to rotation of the body around a second axis perpendicular to the first axis, and the circuit is further configured to produce a second function command when the second signal indicates rotation of the body around the second axis exceeding a respective speed threshold.

52. The device of claim 51 wherein the sensor is further configured to produce a third signal corresponding to movement of the body along a third axis perpendicular to the first and second axes, and the circuit is further configured to produce a third command when the third signal indicates movement of the body along the third axis.

53. The device of claim 42 wherein the sensor is a micro-electro-mechanical type sensor.

54. The device of claim 1 wherein the first and second directions are axes of rotation.

55. The device of claim 1 wherein the MEMS acceleration sensor is configured to detect movements of said device in a third direction.

56. The device of claim 55 wherein the third direction is vertical displacement.

57. The method of claim 16 wherein the first threshold comprises a first X axis threshold and a first Y axis threshold.

58. The method of claim 16 wherein the second threshold comprises a second X axis threshold and a second Y axis threshold.

59-62. (Cancelled)

63. A device for user control of a computer system, comprising:
a body;
a sensor coupled to the body and configured to detect a position of the body in a three dimensional space and to produce a corresponding output signal; and
a circuit configured to:
compare first X and Y output signals from the sensor with second X and Y output signals from the sensor and derive a change of position of the body from the first and second X and Y output signals,
determine, from the change of position, a rate of change,
compare the rate of change of position with a rate of change threshold,
and,
only if the rate of change does not exceed the rate of change threshold,
produce a pointer control signal corresponding to a direction of movement of the body.

64. The device of claim 63 wherein the circuit is configured to compare the amplitude of change with an amplitude threshold and produce the pointer control signal only if the amplitude of change exceeds the amplitude threshold.

65. The device of claim 63 wherein the circuit is configured to produce the pointer control signal to move a screen pointer in a direction corresponding to the direction of movement of the body, and to move the screen pointer at a speed that is directly related to the amplitude of change.

IX. EVIDENCE APPENDIX

Appendix A is a clean copy of the specification incorporating amendments made thereto in filings of October 4, 2006, and February 14, 2008.

Appendix B is a non-patent prior art reference relied upon by the Examiner, entitled “Two Dimensional Position Detection System with MEMS Accelerometer for Mouse Applications,” by Lee, et al.

Appendix C is a Final Office Action mailed May 6, 2008.

A. Clean Copy of Specification Incorporating Amendments

USER CONTROLLED DEVICE FOR SENDING CONTROL SIGNALS TO AN ELECTRIC APPLIANCE, IN PARTICULAR USER CONTROLLED POINTING DEVICE SUCH AS MOUSE OR JOYSTICK, WITH 3D-MOTION DETECTION

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a user-controlled device, in particular a mouse or a joystick, with 3D motion detection. The invention is however also applicable to game pads, trackballs and other screen pointing devices for a computer system as well as to devices for pointing or selecting predetermined tasks or information according to their position, which are connected to a computer or a computer-controlled system. The invention is also applicable to the control of an electrical appliance, e.g., for switching on an electrical appliance and activate particular tasks, on the base of a 3D movement signal generated by the user-controlled device.

Description of the Related Art

As is known, mice are now the most common interface between a person and a computer or a computer controlled device and are hand-displaced on a plane or two-dimensional surface to control a cursor or pointer or activate particular tasks. To this end, typical mice comprise a plurality of sensors detecting a 2D movement of the mouse; a plurality of buttons for entering commands and a communication interface for communication with the computer system.

In view of the ease of operation and spread in use of mice as a convenient interface with computer systems, a number of functionalities are being developed to make mice still easier to use, to reduce operation stresses and damages to arms and shoulders, to increase the number of tasks that may be

controlled or selected through a mouse, to adapt to various specific requirement and operation environment or to detect movements with more degrees of freedom.

For example, a mouse has been proposed, having improved movement detection capabilities, including detection of tilting in four different directions, rotation about its axis and a little vertical movement. This mouse, described, *e.g.*, in “The VideoMouse: A Camera-Based Multi-Degree-of-Freedom Input Device,” by K. Hinckley et al., ACM UIST’99 Symposium on User Interface Software & Technology, *CHI Letters* 1 (1), pp. 103-112, uses a video camera for detecting the movement. However, although the image processing systems are becoming cheaper and smaller, the costs and dimensions of these systems do not allow their use in all systems. Furthermore, this type of movement detection has a functionality highly dependent upon light conditions and/or optical features of the surface the mouse rests on.

Furthermore, the known solutions do not always allow operation by disabled persons, having limited or no hand control.

BRIEF SUMMARY OF THE INVENTION

An embodiment of the invention improves a user controlled device of the indicated type, so as to allow a wider applicability.

According to various embodiments of the present invention, there is provided a user controlled device, and a method for generating control signals.

According to an aspect of the invention, the user controlled device accommodates an accelerometer or acceleration sensor made with the MEMS (MicroElectroMechanicalSystem) technology and able to detect 3D movements, in particular movements around two perpendicular axes, so as to sense the movement of the user controlled device in the space and send corresponding control signals to an electrical appliance, *e.g.*, a computer system.

According to a first embodiment, the user controlled device is similar to a conventional mouse with buttons, wheels and click possibilities, but instead of

being configured so as to be displaceable in a plane, has a support allowing tilting of the device around two perpendicular axes. The support may allow a vertical displacement of the device body.

According to another embodiment, the user-controlled device is an aid device for disabled individuals, in particular for persons having a reduced residual mobility and can, *e.g.*, only move the head. The control device has a housing accommodating a dual-axis MEMS accelerometer operating as an inclinometer; the housing is worn by the person and fixed to a mobile limb or head. For example, the housing may be similar to the housings used for hearing aids, and may be supported in the eyeglass arm, or be fixed to the head through a hairband.

According to another aspect of the invention, the control device is connected through a wire or in a wireless way to the computer system.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For the understanding of the present invention, preferred embodiments thereof are now described, purely as a non-limitative examples, with reference to the enclosed drawings, wherein:

Figure 1 shows a perspective view of a first embodiment of the present control device;

Figure 2 is a lateral view of the pointing device of Figure 1;

Figure 3 shows a perspective view of a second embodiment of the present control device;

Figure 4 shows a perspective view of a third embodiment of the control device;

Figure 5 shows a perspective view of a fourth embodiment of the control device;

Figure 6 shows a perspective view of a fifth embodiment of the control device;

Figure 7 shows a perspective view of a sixth embodiment of the control device;

Figure 8 is a block diagram of the pointing device of Figures 1-7;

Figure 9 is a different block diagram of the control device of Figures 1-7;

Figure 10 is another block diagram of the control device of Figures 1-7; and

Figure 11 is flow-chart of the operation of the pointing device of Figure 6 or 7.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a first embodiment of the present control device, in the shape of a mouse 1. The mouse 1 comprises a body 2 of rounded shape having two buttons 3 and a central wheel 4 operable by the user, in a per se known manner. In the alternative, a middle button may be provided instead of the wheel.

The body 2 is supported by a curved base 5 preferably in the shape of a spherical cap arranged with the convexity looking downwards, so as to allow tilting of the body 2 around two axes A and B, perpendicular to each other and to a vertical axis C. The curved base 5 may be of rigid or resilient material (*e.g.*, rubber), to allow a vertical displacement of the body 2.

The body 2 accommodates the usual control circuitry (not shown), for detecting actuation of the buttons 3 ("clicking") and rotation of the wheel 4 in a per se known manner and sending suitable signals to a computer system (see Figures 7-9). Furthermore, the body 2 accommodates a 3D-motion detection device 7 (the block diagram whereof is shown in Figures 7-9) based on a MEMS accelerometer detecting the acceleration and movement of the body, in particular the tilting of the body 2 around axes A and B and in case vertical displacement along the axis C and sending corresponding information or control signals toward the computer

system. The transmission circuitry may be in common with the usual button and wheel control circuitry.

In the shown embodiment, an electrical wire 8 connects the mouse 1 with the computer system; in the alternative and in a per se known manner, the mouse 1 may be connected wireless (*e.g.*, by optical or radio transmission) to the computer system.

The mouse 1 is designed to be balanced and to rest in an horizontal position in the absence of external forces and to tilt around axis B (up-down movement of the front portion bearing the buttons 3 and the wheel 4) and/or around axis A (left-right movement) under the pressure of a user's hand. The 3D-motion detection device 7 (as discussed in detail with reference to Figures 7-9) detects the tilting and in case the vertical displacement and generates corresponding signals to control an arrow on a screen of the computer system. In particular, the left-right mouse movement (around axis A) may cause a corresponding left-right movement of an arrow on the screen; the up-down mouse movement (around axis B) may cause a corresponding up and down movement on the screen; the vertical movement may control further functions, for example for handling more folders on the screen or performing other pre-programmed dedicated tasks.

Figure 3 shows a different embodiment, wherein the body 2 is supported by a suction cap 40 and a spring 41 is interposed between the suction cap 40 and the body 2. By virtue of the spring 41, the body 2 may be tilted around axes A and B and be displaced along axis C, and a 3D-motion detection device (not shown) arranged inside the body 2 sends corresponding control signals to a computer system. In the alternative, more springs, *e.g.*, four springs, may be provided for a better tilting control, as schematically represented by dashed lines.

Figure 4 shows another embodiment, wherein the body 2 is supported by four balls 45, *e.g.*, of rubber. Also here, the body 2 may perform a tilting movement around axes A, B and vertical displacement along vertical axis C,

and a 3D-motion detection device (not shown) arranged inside the body 2 sends corresponding control signals to a computer system.

Figure 5 shows another embodiment, wherein the control device is a joystick 47, having usual buttons for function control and accommodating a 3D-motion detection device 7.

Figures 6 and 7 show different embodiments specifically intended for disabled persons. In this case, a pointing device 10 includes a housing 15 fixedly attached to an article worn by the user.

In Figure 6, the housing 15 is attached to a hairband 16 and accommodates the 3D-motion detection device 7, shown with dashed lines; the pointing device may be connected to the computer system through a wire 8 or, preferably, in a wireless way.

In Figure 7, the housing 15 is attached to an arm 18 of a pair of glasses 19.

In both cases, tilting of the head of a user up-down and/or left-right causes tilting of the pointing device around axes A, B, as visible in the enlarged detail of Figure 6, and sending of corresponding signals to the computer system, analogously to the embodiments of Figures 1-5. In addition, the pointing device 10 may be designed to associate specific movements of the housing 15 to “click” functions, as below described in greater detail with reference to the flow-chart of Figure 11.

A first embodiment of the 3D-motion detection device 7 is shown in Figure 8. Here, the 3D-motion detection device 7 includes a 2-axis accelerometer 20 manufactured in the MEMS technology, for example as described in European patent application N. 02425320.5 filed on 21.5.2002. Accelerometer 20 generates two output signals X, Y proportional to the tilting angle of the mouse 1 or of the pointing device 10 around axes A, B. Output signals X, Y are digitized in an analog-to-digital converter 21 and fed to a microcontroller 22. Microcontroller 22 may also receive further control signals, such as “clicking” signals from the buttons

3 and position signals from the wheel 4 in the embodiments of Figures 1-5, as indicated with dashed line.

The 3D-motion detection device 7 also includes a communication port 23, for example, an RS 232 or USB port for signal exchange between the microcontroller 22 and a computer 25 including, i.e., a central unit 26, a screen 27 and a keyboard 28.

In case of the mouse 1 or the pointing device 10 allow vertical displacement, a further accelerometer 29 may be provided to send a corresponding signal to AD converter 21 and microcontroller 22, as shown in dashed line.

Figure 9 shows a second embodiment of the 3D-motion detection device 7 comprising, instead of a 2-axis accelerometer, two 1-axis accelerometers 30 and, in case, a vertical axis accelerometer 29, all manufactured in the MEMS technology. For example, the accelerometer described in U.S. Application No. 10/128,133 filed on April 23, 2002 or the accelerometer described in US 5,955,668 may be used. In this case, the accelerometers 30 are arranged so that one accelerometer 30 detects tilting around axis A and the other accelerometer 30 detects tilting around axis B, while accelerometer 29 detect displacement along axis C, and generate respective output signals X, Y and Z.

Figure 10 shows a third embodiment including a 2-axis accelerometer 20 as in Figure 8, but communication with the computer 25 is accomplished through a radio-frequency link (e.g., using the Bluetooth technology). Here, the microcontroller 22 is connected with an RF transmitter/receiver 31 which, through antennas not shown, communicates with an interface 32 including an analogous RF transmitter/receiver 33 and a digital port 34, e.g., an RS 232 or USB port, in turn connected with the computer 25.

In the case of the mouse 1, the 3D-motion detection device 7 detects the tilting movements of the body 2 and controls the position of an arrow or other pointer on the screen 27 on the basis of the output signals X and Y fed by the 2-

axis accelerometer 20 or the 1-axis accelerometers 30 in a manner analogous to conventional mice.

In case of vertical displacement, signal Z may be used according to the pre-programmed task.

In case of the pointing device 10, as said, the microcontroller 22 may control not only the shifting of an arrow on the screen 27, but also “clicking” functions, based, *e.g.*, on the variation speed, *i.e.*, the rate of change, of the output signals X, Y fed by the accelerometer(s) 20, 30. Conveniently, the microcontroller 22 is able to discriminate among unintentional small movements (*e.g.*, tremors) of the user’s head, intentional movements of bigger entity for pointer position control and rapid head movements for “clicking.”

To this end, the microcontroller compares the entity of the detected movements (difference between the current and previous output signals X and Y, fed by the accelerometer) with a click threshold to detect a clicking movement, and, if a clicking movement is not detected, the microcontroller compares the signals X and Y with respective thresholds THX and THY to detect arrow control movements.

In particular, when an arrow control movement is detected (slow movement of the head), the signs of the signals indicate the direction (up, down, left, right) of the arrow movement with a speed which is a function of the amplitude of the signals. When instead a clicking function is detected, the sign of the derivative of one output signal indicates simple clicking of the left or of the right button, and the sign of the derivative of the other output signal indicates continuous pressure of the left button or interruption of the continuous pressure, as below described in detail.

The thresholds may be programmed by the user in a setup phase of the pointing device 10, as well as the functions associated with slow or rapid movement.

A flow-chart of the control program of the microcontroller 22 for the embodiments of Figure 6, 7 is shown in Figure 11.

Initially, step 50, thresholds THC, THX, THY, and constants Kx, Ky are initialized. Threshold THC represents the clicking threshold, that is the minimum derivative in absolute value for controlling a clicking function; THX represents the X-signal threshold, that is the minimum signal in absolute value for recognizing a valid movement along the X axis and THY represents the Y-signal threshold, that is the minimum signal in absolute value for recognizing a valid movement along the Y axis. Kx and Ky represent the desired movement speed.

Then, the (digitized) output signals X and Y from the accelerometer(s) 20, 30 are read, step 52; the entity of the movement in the X direction is calculated as the difference between the output signal X and a previous value XOLD, and represents the amount of change of position in the X direction since the previous value XOLD was read. The resulting value is compared with positive clicking threshold THC, step 54. If the difference X-XOLD is higher than the positive clicking threshold THC, indicating a rate of change that exceeds the threshold THC, a right click (corresponding to clicking of the right button in a conventional mouse) is detected and a corresponding signal is sent to the computer system, step 56; otherwise the difference X-XOLD is compared with the negative clicking threshold -THC, step 58. If the difference X-XOLD is lower than the negative clicking threshold -THC, a left click (corresponding to clicking of the left button in a conventional mouse) is detected and a corresponding signal is sent to the computer system, step 60.

If the difference X-XOLD is higher than negative clicking threshold -THC but lower than positive clicking threshold THC, output NO from step 58, the absolute value of the signal X is compared with X-signal threshold THX to discriminate between an unintentional small movement and a control movement, step 62. If the absolute value of the signal X is higher than X-signal threshold THX, a new position X_POS of the mouse on the screen is calculated by adding a

quantity $K_x \cdot X$, proportional to the detected output signal X , to the previous position $OLDX\_POS$ and a corresponding signal is sent to the computer system, step 64.

If the absolute value of the signal X is lower than the X -signal threshold THX (output NO from step 62), as well as after detecting a clicking function (after steps 56, 60) and after calculating the new position X_POS (after step 64), the variation of the output signal Y is checked, analogously to what has been described for the X signal. Thus, the entity of the movement in the Y direction is calculated as the difference between the output signal Y and a previous value $YOLD$ and compared with positive clicking threshold THC , step 66. If the difference $Y-YOLD$ is higher than the positive clicking threshold THC , a command analogous to the continuous pressure of the left button in a conventional mouse is detected and a corresponding signal is sent to the computer system, step 68; otherwise the difference $Y-YOLD$ is compared with the negative clicking threshold $-THC$, step 70. If the difference $Y-YOLD$ is lower than the negative clicking threshold $-THC$, a release command of the left button is detected and a corresponding signal is sent to the computer system, step 72.

If the difference $Y-YOLD$ is higher than negative clicking threshold $-THC$ but lower than positive clicking threshold THC , output NO from step 70, the absolute value of the signal Y is compared with Y -signal threshold THY , step 74. If the absolute value of the signal Y is higher than Y -signal threshold THY , a new position Y_POS of the mouse on the screen is calculated by adding a quantity $K_y \cdot Y$, proportional to the detected output signal Y , to a previous position value $OLDY\_POS$ and a corresponding signal is sent to the computer system, step 76.

If the signal Y is lower than the Y -signal threshold THY (output NO from step 74), as well as after detecting a continuous clicking or clicking release function (after steps 68, 72) and after calculating the new position Y_POS (after step 76), the previous values $XOLD$, $YOLD$, $OLDX\_POS$ and $OLDY\_POS$ are updated with the current values X , Y , X_POS and Y_POS , step 78.

The cycle continues until the pointing device is switched off.

The advantages of the present invention are clear from the above. In particular, it is outlined that the detection of a 3D movement by way of an MEMS accelerometer causes the control device to be very versatile as regards application, features and operativity. In particular, the control device may be implemented as a mouse, joystick, trackball, control pad or other control device for a screen cursor or for selection among a number of alternatives presented on a screen or other display. The device may be implemented to allow a simple actuation, also by persons having reduced movement capabilities; and additional control may be implemented by a same control device.

Furthermore, the implementation as a mouse requires an actuation space smaller than with actual mice, since no planar movement on a resting surface is required. Furthermore, no mouse pad is needed, and the present pointing device may be actuated on top of any surface, independently from the texture or optical properties thereof.

The control device with 3D-movement detection by MEMS accelerometers manufactured using semiconductor technologies is cheaper than other prior solutions.

The device may be used to control actuation of different operations or tasks of an electrical appliance, which is very advantageous for disabled persons or in case that the user should require the hands free for other activities.

Finally, it is clear that numerous variations and modifications may be made to pointing, selection or, generally, control device described and illustrated herein, all falling within the scope of the invention as defined in the attached claims.

In particular, the pointing, selection or control device may be implemented in any support, such as any mouse, joystick, gamepad, PDA (personal digital assistant, allowing Web surfing, e-mail exchange and so on), mobile phone, that is 3D-movable or has a 3D-movable portion.

Furthermore, the shape of the support allowing tilting of the device body may vary; for example, in the embodiment of Figure 4, the yieldable balls may be replaced by rigid balls connected to the body 2 through elastic means.

All of the above U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet, are incorporated herein by reference, in their entirety.

(OMITTED)

CLAIMS

ABSTRACT OF DISCLOSURE

A user controlled device, movable into a plurality of positions of a three-dimensional space, includes a MEMS acceleration sensor to detect 3D movements of the user controlled device. The device, such as a mouse, sends control signals correlated to the detected positions to an electrical appliance, such as a computer system. A microcontroller processes the output signals of the MEMS acceleration sensor to generate the control signals, such as screen pointer position signals and “clicking” functions.

Two-Dimensional Position Detection System with MEMS Accelerometer for MOUSE Applications

Seungbae Lee, Gi-Joon Nam, Junseok Chae, Hanseup Kim, and Alan J. Drake

PD-1800-2001
P. 852-857

Department of EECS, University of Michigan
Ann Arbor, MI 48109-2122
saungbae@criteri, jchaee, hanseup, ajdrake}@eecs.umich.edu

ABSTRACT

A hybrid two-dimensional position sensing system is designed for mouse applications. The system measures the acceleration of hand movements which are converted into two-dimensional location coordinates. The system consists of four major components: 1) MEMS accelerometers, 2) CMOS analog read-out circuitry, 3) an acceleration magnitude extraction module, and 4) a 16-bit RISC microprocessor. Mechanical and analog circuit simulation shows that the designed padless mouse system can detect accelerations as small as 5 mg and operate up to 18 MHz.

1. INTRODUCTION

Most commercial mouse systems are built with rolling-ball or optical technology to provide cursor positions. For example, a ball mouse system detects physical rolling movements of the ball, which are affected by a non-flat or obstructed surface. An optical mouse system avoids these environmental factors by detecting the reflection of light on a reflective supplementary pad. Both technologies, however, require a special surface limiting the working space and freedom of the user's movements. Obviously, a more desirable mouse system would not be restricted by environmental factors.

In this paper, we describe a novel mouse system design which detects two-dimensional positions without any additional components such as pads. Shown in Figure 1, the system consists of four major components: 1) MEMS (Micro Electro Mechanical Systems) accelerometers, 2) CMOS analog read-out circuitry, 3) an acceleration magnitude extraction module, and 4) a 16-bit RISC microprocessor. Two MEMS accelerometer devices are employed to measure X and Y -axis acceleration of the movements from the user's hand. These acceleration values are pulse width modulated by the CMOS analog read-out circuitry and will be converted into (X, Y) coordinates on the screen by performing integral operations using a 16-bit RISC microprocessor. In this design, we present a hybrid configuration system, which means each component is not based on the same substrate and thus has to be interfaced with each other by means of external connections. The MEMS device is designed in S.O.I. (Silicon On Glass) technology developed at the University of Michigan. The analog readout circuit is designed in a dual-poly, single-metal process, also developed at the University of Michigan and the digital microprocessor is designed in a 1.5 μ m AMI process through MOSIS using SCMOS design rules.

The rest of this paper is organized as follows. Section 2 presents the overall system architecture and explains each module in detail. Section 3 describes the verification and testing methodology for our system. Section 4 reports the statistical data of the final design. Sec-

tion 5 describes monolithic implementation of the mouse as future work with conclusion in Section 6.

2. SYSTEM OVERVIEW

2.1 System Requirements and Constraints

Two system requirements stand out for consideration: speed and accuracy. Generally the speed of physical reaction from a human is remarkably slow compared to the speed of a modern microprocessor and it is reported that the magnitude of an action is at most on the order of 10^{-2} seconds [1]. Since the mouse system must generate (X, Y) coordinate values faster than this rate, the target clock frequency was chosen to be 100 kHz, which provides 500 instructions per coordinate calculation. In terms of movement accuracy, the finest acceleration from a human hand is more than 10 mg ($g=9.8\text{m/s}^2$). One of the most important figures of merit in MEMS accelerometers is sensitivity which is defined as the capacitance variation per acceleration change. The capacitance change due to acceleration input is detected and converted to a voltage in analog read-out circuits. Accordingly, together with the MEMS accelerometer's sensitivity, the gain and equivalent input noise of the analog read-out circuits determine the overall minimum detectable acceleration. The analog read-out circuits and MEMS accelerometer are designed to detect acceleration as small as 5 mg so that our system can catch the smallest movement of the human hand.

2.2 Design Methodology

A nonpositive sensing configuration, as shown in Figure 2, was chosen for the MEMS accelerometer because it gives high sensitivity with low temperature drift [4]. The device dimensions optimize large sensitivity over layout area and its functionality was verified using ANSYS.

For the analog read-out circuit design, switched capacitor circuits were chosen to simplify the interface between the analog and the digital parts. All the analog circuit designs were simulated with HSPICE and laid out using Mentor Graphics software.

A top-down approach was used to partition the design into its various analog, digital, and MEMS components. Each module was verified using a bottom-up approach for timing, functionality, and LVS. The majority of modules—the microprocessor datapath, analog circuitry, and MEMS devices—are full custom designs while the microprocessor controller was designed using Verilog HDL.

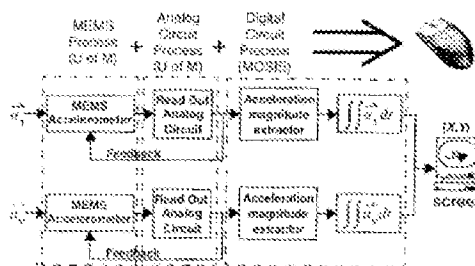


Figure 1. Block diagram for the hybrid MOUSE system.

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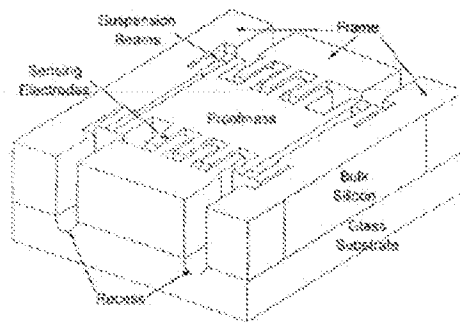


Figure 2. S.O.G MEMS accelerometer.

2.3 Operational Overview

Figure 1 shows an operational block diagram of the mouse system. When a user moves the mouse in an arbitrary direction, the acceleration is decomposed into X- and Y-axis acceleration components by a corresponding "MEMS accelerometer". The actual acceleration value is represented by a differential capacitance between two capacitors in the MEMS device. This capacitance value is simultaneously fed back to reset the MEMS device—so the next acceleration can be measured without any bias—and fed forward into the CMOS analog read-out circuitry where it is converted into a digital pulse-width modulated output voltage. The polarity of the pulse, either positive or negative, determines the direction of the acceleration and the width of the pulse is proportional to the magnitude of the acceleration. An "acceleration magnitude extractor" changes the generated pulse width into the units of system clock frequency, which will be used by the microprocessor to calculate the exact position coordinate values on the screen.

2.4 MEMS Accelerometer

Typically, there are three different types of MEMS accelerometers, piezo-resistive [3], inverting [3], and unipolar [4, 5]. The capacitive accelerometer was chosen for this system because it provides high sensitivity, good DC response, low drift, low temperature sensitivity, low-power dissipation, and a simple structure [6]. S.O.G technology was chosen for the implementation, instead of some other technology, to take advantage of its robustness and simplicity of design.

Figure 2 shows the structure of a S.O.G lateral accelerometer [4]. A MEMS accelerometer consists of two major components: a proof mass and sensing electrodes. A proof mass and sensing electrodes are connected to a frame which is anchored to a glass substrate. Since the proof mass is suspended over a recess on a glass substrate with serpentine suspension beams, it is free to move in response to an external acceleration. Electrodes attached to the glass substrate are stationary. When external forces are applied to the accelerometer (by the user's hand movement, for example), the proof mass moves against the forced direction due to an inertia force while the electrodes remain stationary. The movement causes capacitance variations between the comb fingers which form parallel plate capacitors, denoted as ΔC . One side of the comb fingers generates a positive variation ($+\Delta C/2$), and the other side produces a negative one ($-\Delta C/2$). The total capacitance change is the difference between these two values [$(+\Delta C/2) - (-\Delta C/2)$]. Therefore, the external acceleration is converted to the differential capacitance variation which can be expressed as:

$$\Delta C(pF/g) = \frac{(8 \cdot M)}{k \cdot l_g} \cdot C_p \quad (1)$$

where M is the mass of the proof mass, C_p is the rest capacitance, l_g is the sensing gap distance, and k is the spring constant of the sus-

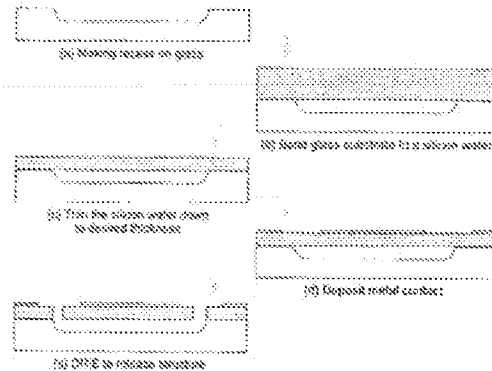


Figure 3. Fabrication process sequence

pension beams[5]. From Eqn.(1), it can be expected that a heavy accelerometer with a large number of comb fingers and compliant structure—i.e., small spring constant—provides good sensitivity, although it is difficult to fabricate such accelerometers. A single crystal silicon proof mass 2.1 mm wide, 2.4 mm long, and 100 μ m high gives 0.78 pF/g sensitivity. For the two-dimensional mouse system, two lateral accelerometers are required for sensing X and Y-axis accelerations. A schematic top view of the MEMS accelerometer in Figure 2 is shown in Figure 5.

The fabrication process has 5 steps, requiring only 3 masks developed at the University of Michigan. Figure 3 shows the cross section of the wafer for each fabrication step and Figure 4 shows an SEM (Scanning Electron Microscope) picture of a MEMS accelerometer taken after fabrication.

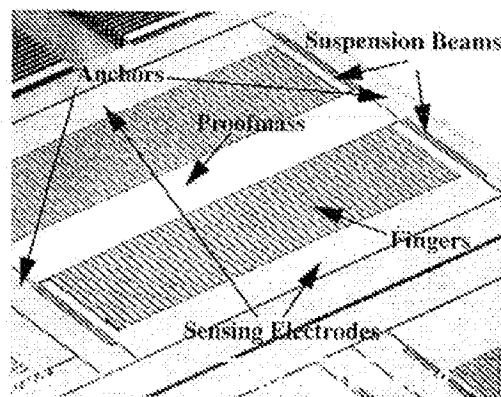


Figure 4. Top view of a MEMS accelerometer.

2.5 CMOS Analog Read-Out Circuits

The detected acceleration, which represents a differential capacitance variation from the MEMS accelerometer, is modulated by the analog read-out circuitry shown in Figure 5. In general, the lateral accelerometer presented in Section 2.4 can be operated either in open-loop mode or closed-loop mode. In closed-loop operation the overall performance such as linearity, dynamic range, and bandwidth are improved [6]. In our design, an electromechanical over-

sampler modulator is used because it provides direct digital output and hence feedback control of the proof mass simultaneously over a wide dynamic range.

A switched capacitor front-end, shown in Figure 5 (a), was chosen because it is insensitive to the input parasitic capacitance. An efficient gain and offset compensated integrator is obtained by using an offset-storage capacitor, C_{off} , and a correlated double sampling (CDS) technique [7]. This circuit uses a single-ended charge integrator to read out the capacitance variation and the static comparator forms the loop quantizer. Finally, a digital flip-flop samples the output from the comparator and synchronizes its bit stream with the system clock. Since the proof mass can be modeled as a second order system the closed loop system becomes unstable so a simple lead compensator, $H_c(z)$, is inserted in the feedback path for stability.

There are four clock phases in the switched-capacitor interface circuit. During the first phase (ϕ_1) the sense capacitors formed between the electrodes and the proof mass are reset and the Op-amp offset voltage is stored on C_{off} . In the second phase (ϕ_2) sense capacitors, C_{top} and C_{bot} are charged through V_+ and V_- . The charge difference between C_{top} and C_{bot} is integrated on the feedback capacitor, C_f , while the comparator quantizes the charge. In this phase, the offset voltage stored on C_{off} is subtracted and thus the output offset voltage of the Op-amp is compensated. The amplitude of the Op-amp output voltage corresponds to the magnitude of the applied acceleration. For example, if the MEMS device gets positive acceleration, then the proof mass is closer to the left anchor of the MEMS accelerometer and C_{top} is bigger than C_{bot} . Since C_{top} is connected to the negative reference voltage (V_-), the negative net charge is sampled to an integrator, generating a positive Op-amp output voltage. The capacitance sensitivity defined as the Op-amp output voltage due to input capacitance change (ΔC) is calculated by:

$$V_o = \left(\frac{\Delta C}{C_f} \right) (V_+ - V_-) \quad (2)$$

From Equ.(2) the capacitance sensitivity is approximately 0.33 V/pF. The quantized output is also latched at the end of this phase. In the last phase (ϕ_3) the output of the flip-flop is fed back to the MEMS accelerometer to place the proof mass in the nulling position by electrostatic forces. An additional phase (ϕ_4) is used for the control and sensing of the proof mass. The output of the latch forms pulse bit streams for the next module.

Figure 6 shows the HSPICE simulation result of the modulation of acceleration magnitudes into the corresponding digital pulse bit streams (PWM signal). The layout for the analog read-out circuit is shown in Figure 7.

2.6 Noise Analysis of Closed Loop System

There are several noise sources that affect the performance of the overall system determining the minimum detectable input acceleration. In an oversampled electro-mechanical sigma-delta system, higher sampling rates reduce the quantization noise and result in a 3

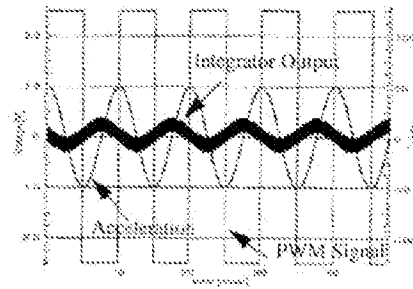


Figure 6. HSPICE simulation for analog read-out circuit.

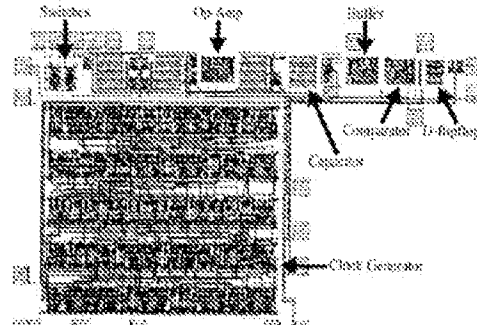


Figure 7. Layout for Sigma-Delta analog readout circuitry. (die size: 4.5mm x 2.6mm)

dB signal-to-noise ratio improvement for each doubling of the sampling frequency. Each noise source will now be described.

• Brownian noise:

The primary mechanical noise source for this device is due to the Brownian motion of gas molecules between comb fingers. The total noise equivalent acceleration (TNEA): $\frac{m \langle \dot{x} \rangle^2}{M} \frac{dH(z)}{dz}$ [16] is

$$TNEA = \frac{\sqrt{4k_B T D}}{M} = \sqrt{\frac{4k_B T w_c}{Q M}} \quad (3)$$

where, k_B is the Boltzmann constant, T is the temperature in Kelvin, D is damping coefficient, and w_c is resonance frequency. From

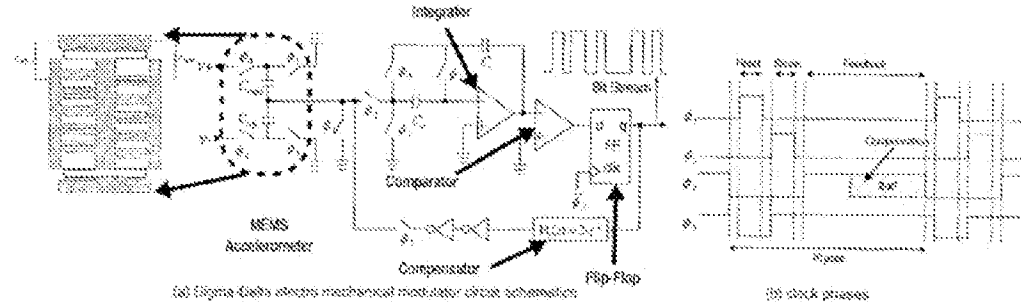


Figure 8. Sigma Delta Electro Mechanical Modulator with clock phases

Eqn.(3), it is seen that the MEMS accelerometer has smaller Brownian noise with larger Q and heavier proof mass. Plugging device data into this equation results in Brownian motion noise around $10 \mu\text{g}/\sqrt{\text{Hz}}$.

• Amplifier noise:

The readout circuitry utilizes correlated double sampling to reduce the input CMOS amplifier flicker noise; however, the amplifier thermal noise is amplified by the ratio of total input capacitances, including parasitics in the integrating capacitor. The noise at the output of the amplifier can be expressed by integrating the total noise power and dividing it by the effective noise bandwidth, which is half the sampling frequency. Therefore, the amplifier output noise voltage due to thermal noise in the Op amp is expressed as:

$$V_{Amp-out} = \sqrt{\frac{16}{3} \frac{C_T}{C_i} \frac{1}{f_s} \frac{1}{C_{out}}} \quad (4)$$

where C_T is the total input capacitance including parasitics, C_{out} is the capacitance of the Op amp output node, and f_s is the sampling frequency. From this equation, the equivalent input acceleration noise due to amplifier thermal noise is about $0.7 \mu\text{g}/\sqrt{\text{Hz}}$.

• kT/C noise:

A major noise source in switched capacitor circuits is kT/C noise which is generated by the CMOS switch thermal noise. The rms voltage noise from thermal switch noise can be calculated by the integration of the bandwidth of the switch's RC filter. The voltage noise power density due to this switch thermal noise is expressed as:

$$V_{kT/C-out} = \sqrt{\frac{4kT}{C_i}} \quad (5)$$

This kT/C voltage noise is converted to equivalent input acceleration noise as $0.3 \mu\text{g}/\sqrt{\text{Hz}}$.

• Mass residual motion noise:

The proof mass is being rebalanced by a pulse train and thus it has a residual motion with a small ac amplitude. The amplitude of this motion can be shown [6] to be approximately equal to $\Delta x = 4 a_{mass}/(\pi f_s)^2 = 8.0 \times 10^{-7} \text{m}$ with $a_{mass} = 20\text{g}$ and $f_s = 1000 \text{Hz}$. This residual motion corresponds to an equivalent rms of 78mg acceleration in this MEMS accelerometer. This acceleration can be randomized due to the varying input and hence it can be considered to be noise distributed uniformly from dc to the proof mass residual motion frequency $f_s/4$. This noise is then equivalent to $500 \mu\text{g}/\sqrt{\text{Hz}}$.

• Dead Zone Noise:

Assuming that the input of the accelerometer is zero, the feedback voltage generator a_{out} with frequency $f_s/4$ because of electrostatic force. Therefore, the input signal must be large enough to break this dead-zone pattern. The minimum rms input acceleration for this is $a_{dead-zone} = 80_{rms}/(f_s/4)^2 = 160 \mu\text{g}$, and should be avoided as noise.

• Total noise and Minimum detectable acceleration:

Since all of the noise sources considered here are uncorrelated they may be summed giving a total noise of $530 \mu\text{g}/\sqrt{\text{Hz}}$. Therefore, the minimum detectable acceleration is the same as the one calculated by integrating this input acceleration density over the bandwidth of interest, $\sim 100 \text{Hz}$. The resultant minimum detectable acceleration is 5.3mg , which is below the smallest acceleration a human hand can generate/perceive. From the noise source consideration, we see that the mass residual noise dominates with order of magnitude. However, this mass residual motion noise can be significantly reduced by increasing the sampling frequency at the cost of power consumption and complexity.

2.7 Acceleration Magnitude Extractor

The modulated pulse bit stream from the CMOS analog read-out circuit is converted into binary data for further processing. Two types of data should be extracted from the pulse bit streams: polarity and magnitude. The polarity indicates the direction of acceleration,

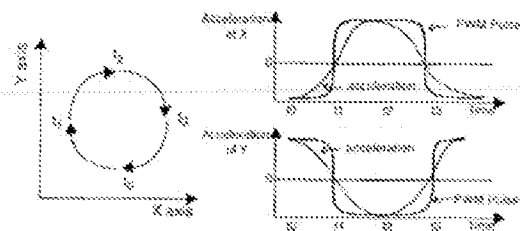


Figure 8. Movements of a mouse and corresponding accelerations in X- and Y-axis.

and can be readily extracted by observing the sign of pulse bit streams. For example, Figure 8 illustrates the movements of the mouse and corresponding acceleration values on both the X- and the Y-axis. It also shows the possible PWM (Pulse Width Modulation) bit streams. If the value of the pulse is 5 volts (digital value "1"), the acceleration is toward the positive direction, and vice versa. The width of the pulse bit streams is proportional to the magnitude of acceleration. The extraction of correct magnitude of acceleration can be achieved via two binary flags (flip-flops) and a binary counter as shown in Figure 9. The "c" flag is set to the polarity of the current

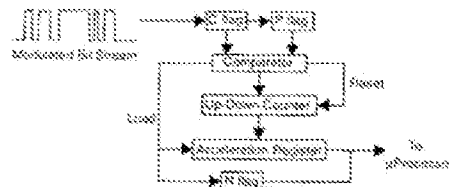


Figure 9. Acceleration Magnitude Extractor.

input pulse bit stream synchronized by the system clock, while the "p" flag value is the one shifted from the "c" flag flip-flop in the previous clock cycle. The comparator compares the two flag values and whenever two flag values differ—i.e. the polarity of the input stream changes—it loads the current value of the binary counter into the "acceleration register" and at the same time resets the counter. While the "c" and "p" flags have the same value, the counter keeps increasing or decreasing based on the value of the "c" flag. Thus, the magnitude of generated values is proportional to the degree of the acceleration of movements, and the polarity of the input bit streams determines the direction of the user's movements. The positive value of the counter corresponds to positive acceleration and vice-versa. The "acceleration register" always keeps some static values specifying the previous acceleration magnitude and the control microprocessor only accesses this register to calculate the current position of the cursor. Whenever the acceleration register loads a new value from the counter, the "n" flag is set to "1" indicating that the new value has been loaded. The control microprocessor keeps polling "n" to decide whether it should fetch a new acceleration value or not. The layout of the acceleration magnitude extractor is assembled together with the core microprocessor shown in Figure 11.

2.8 Core Control Microprocessor

The core control microprocessor is designed to filter the acceleration output from the analog read-out circuitry within the bandwidth of interest and to remove the quantization noise folded at higher frequency as well as other noises. This can be done with a simple FIR low pass filter with $\sim 100 \text{Hz}$ cut-off frequency. Also, the microprocessor calculates the position coordinates based upon the magnitude values of the acceleration from the acceleration extract module. The processor is based on RISC concepts and is implemented as a modified two-stage (fetch/decode and execute) pipeline (Figure 10). Instruction fetch takes place during the half cycle before the instruction

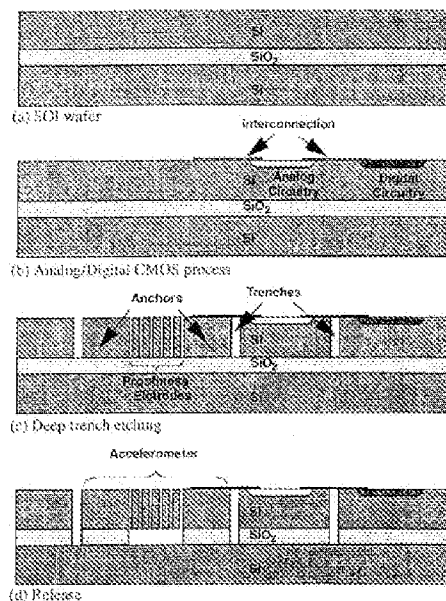


Figure 12. Process flow of monolithic implementation.

on the same wafer, it greatly reduces the overall costs as well as complex steps for the interface. With all these advantages over hybrid system, however, monolithic system has several problems such as noise between analog and digital circuits, interconnections between MEMS devices and analog circuits, and so on. One of the main factor for a noise problem in a monolithic system stems from the fact that the analog and digital circuits are sharing the same substrate. Although substrate has high resistance, it is not a complete isolator and thus voltage variations in digital parts are capacitively coupled to analog circuits and thus may cause malfunctions of a system.

This noise problem due to the substrate coupling can be solved by using Silicon-on-Insulator (SOI) which isolates one module from the other by etching the substrate boundaries of each module and making it isolated both physically and electrically. And more, MEMS accelerometers and analog circuitry can be connected to each other by making deep trenches. It is reported that the silicon substrate underneath interconnection materials such as metals can be removed in the process of deep trench etching because of a sidewall etching effect [11]. The detailed fabrication process (flow for monolithic implementation combining MEMS devices, analog and digital circuits) are basically post CMOS fabrication, presented in Figure 12. The usual CMOS processes are done using SOI start-wafer as shown in Figure 12(a) and (b). After CMOS processes, deep trenches are made for the formation of proofmass of MEMS accelerometer as well as isolation between analog and digital circuitry as given in Figure 12(c). Figure 12(d) presents the release step by removing SiO_2 with BHF to suspend the proofmass. During release, the SiO_2 between analog/digital circuitry are also etched away. Figure 13 shows the mask level MEMS structure. Close-up view shows a interconnection line, contacts, suspension beams, and etch holes which help releasing proofmass during BHF etch process.

6. CONCLUSION

In this paper, we presented a novel two-dimensional position

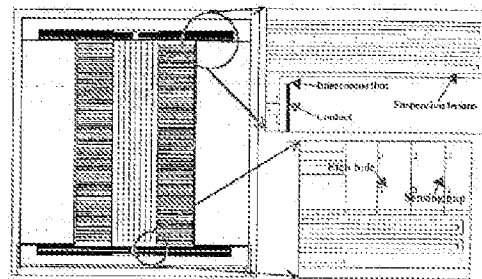


Figure 13. MEMS accelerometer for monolithic

detection system for padless mouse applications that do not require any contacts for proper mouse operation. The design requirements were carefully examined and the systematic design methodology was established. The final system consists of four major components: 1) MEMS accelerometer, 2) Analog read-out circuit, 3) Acceleration magnitude extraction module and 4) 16-bit RISC microprocessor. Each module was carefully designed, laid out, and verified through extensive simulation. The calculated and simulated minimum detectable acceleration is 5.3 mg.

The hybrid multi-chip nature of the proposed system will limit the system size and contribute capacitive and resistive parasitics that may degrade the system performance. To circumvent these drawbacks, a system-on-chip (SoC) design and fabrication, where all the modules are fabricated on a single wafer, are considered as future work in this area. Also, the system can be handily extended into a three-dimensional position detection system by adding an additional MEMS accelerometer to measure Z-axis directional movement.

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C. Final Office Action



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/685,292	10/14/2003	Giuseppe Calarco	854063.736	9819
38106 / 7590 05/06/2008 SBED INTELLECTUAL PROPERTY LAW GROUP PLLC 701 FIFTH AVENUE, SUITE 5400 SEATTLE, WA 98104-7092				
RECEIVED MAY 09 2008 Seed Intellectual Property Law Group PLLC			EXAMINER	
			LIANG, REGINA	
			ART UNIT	PAPER NUMBER
			2629	
			MAIL DATE	DELIVERY MODE
			05/06/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

2 - month Response Due: July 6, 2008
 3 - month Response Due: Aug. 6, 2008
 Notice of Appeal Due: Nov. 6, 2008
 (6 - month period ends) Will Go Aban
 (3 - month extension of the time required)
FINAL REJECTION

ENTERED IN DOCKET

Office Action Summary	Application No.		Applicant(s)	
	10/685,292		CALARCO ET AL.	
	Examiner		Art Unit	
	Regina Liang		2629	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1) ☒ Responsive to communication(s) filed on 14 February 2008.

2a) ☒ This action is FINAL. 2b) ☐ This action is non-final.

3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4) ☒ Claim(s) 1-8 10-14, 16-18, 20, 22, 30-39, 41-45, 48, 50-58, 63-65 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5) ☐ Claim(s) _____ is/are allowed.

6) ☒ Claim(s) 1-8 10-14, 16-18, 20, 22, 30-39, 41-45, 48, 50-58, 63-65 is/are rejected.

7) ☐ Claim(s) _____ is/are objected to.

8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9) ☐ The specification is objected to by the Examiner.

10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)	4) ☐ Interview Summary (PTO-413)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)	Paper No(s)/Mail Date: _____
3) ☐ Information Disclosure Statement(s) (PTO/SD/08)	5) ☐ Notice of Informal Patent Application
Paper No(s)/Mail Date: _____	6) ☐ Other: _____

DETAILED ACTION

1. This Office Action is responsive to amendment filed 2/14/08. Claims 1-8 10-14, 16-18, 20, 22, 30-39, 41-45, 48, 50-58, 63-65 are pending in the application.

2. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

Claim Rejections - 35 USC § 103

3. Claims 1, 2, 8, 12-14, 16-18, 20, 22, 30-34, 36-39, 41, 54-58, 63-65 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (US 6,573,883) in view of Lee et al ("Two-Dimensional Position Detection System with MEMS Accelerometer for MOUSE Applications", hereinafter Lee).

As to claim 1, Fig. 5 of Bartlett discloses a user controlled device (handheld computing device 700), comprising a body, that is movable in a plurality of positions of a 3-D space; a motion sensor (740 in Fig. 5, col. 6, lines 21-26) coupled to the body and configured to detect movements of the body in a first and second directions; a microcontroller (inherent including a microcontroller in the computing device) coupled to the sensor and configured to generate first control signals (position command signals) correlated to the positions, only while detected movements of the body are less than a speed of movement threshold (no gesture command is detected; note that the gesture command as shown in Figs. 2a-2d correspond to a speed threshold, e.g., in Fig. 2a, the quick movement of the handheld has to be greater than the angular orientation about an axis of rotation during the time interval between T_F - T_S , an activation signal is detected, otherwise, the activation signal is not detected, thus, the angular orientation about an

axis of rotation during the time interval reads on a speed of movement threshold or speed threshold as claimed) and greater than a amplitude of movement threshold ($\theta > \theta_1$, see col. 5, lines 35-47).

Bartlett does not disclose the motion sensor comprising a MEMS acceleration sensor. However, Lee teaches a position detection system with MEMS accelerometer, Fig. 1 of Lee also teaches a microcontroller coupled to the MEMS sensor and configured to generate control signals correlated to the positions (page 852). Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the device of Bartlett to utilize a MEMS acceleration sensor to detect movements of the body in a first and second directions since Lee teaches the MEMS accelerometer "gives high sensitivity with low temperature drift" and "the device dimensions optimize large sensitivity over layout area" (page 852, lines 2-4 in [2.2]).

As to claim 2, Bartlett teaches the body of the handheld device is in a form of PDA. Lee teaches the body of the input device is in a form of mouse. And it is well known in the art that user input device comprising a joystick, a game pad. Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the user input device of Bartlett as modified by Lee to be in a form selected between computer mouse, joystick, gamepad, and PDA so as to input commands and information into a computer since such forms are well known and familiar to the user. Furthermore, a change in shape of the input device would have been obvious to one having ordinary skill in the art at the time the invention was made, since a mere change in shape or form involves only routine skill in the art. *In re Dailey*, 149 USPQ 47 (CCPA 1976).

As to claim 8, Lee teaches the MEMS acceleration sensor comprises at least a two-axis accelerometer or two one-axis accelerometers (page 852, 2nd paragraph in INTRODUCTION).

As to claims 12, 33, 34, Bartlett teaches the first control signals comprising a control signal for displacing a screen pointer along a first direction upon detection of movement of the device in the first direction and a control signal for displacing the screen pointer along a second direction upon detection of movement of the device in the second direction (see Fig. 4a, the highlighted selection band corresponds to the screen pointer, move the selection band to the top or to the bottom corresponding to displacing the screen pointer along a first direction or second direction as claimed).

As to claim 13, Bartlett discloses generating second control signals upon detecting movements of the device that are greater than the speed of movement threshold (Fig. 2a, the angular orientation about an axis of rotation during the time interval is reached, and one of gesture command is detected).

As to claims 14, 22, 39, Bartlett teaches that a gesture command (e.g. Figs. 2a-2d) is used to perform a selection function and that the gesture command can be in the same direction as the position command (e.g. col. 4 lines 40-41, "Gesture commands can correspond to a pattern of movement relative to one of the three orthogonal axes") and it is old and well known in the art for input devices (e.g. mouse) to provide cursor movement and mouse click command (selection function) by the user (e.g. Bartlett col. 1 lines 39-43). Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the second control signals in Bartlett as modified by Lee to comprise mouse click function command to allow the user to provide simple cursor movement command and mouse click function command (selection

command) to provide for "completely finger-free data input" for an electronic device (Bartlett col. 2 lines 19-22). It would have been further obvious to include the claimed mouse click mouse functions since it is an obvious substitution of one type of mouse click function for another.

As to claim 30, note the discussion of claim 1 above. Furthermore, the highlighted selection band as shown in Figs. 4a and 4b of Bartlett corresponds to a pointer on a computer screen.

As to claim 31, Bartlett discloses ignoring movement signals that do not exceed an amplitude threshold ($\theta < \theta_1$).

As to claims 32, 38, Bartlett discloses producing activation signals corresponding to movement of the body that exceeds the speed threshold (the angular orientation about an axis of rotation during the time interval is reached, and one of gesture command is detected as shown in Fig. 2a).

As to claim 36, note the discussion of claims 1 and 30 above. Furthermore, it is inherent that the system of Bartlett as modified by Lee having a CPU coupled to the computer screen for controlling the information in the computer screen.

As to claim 37, Lee teaches the MEMS sensor is configured to produce positions signals corresponding to movement of the pointing device around first and second mutually perpendicular axes (X and Y axis).

As to claim 41, Bartlett teaches to control the speed of movement of the pointer (the rate of scrolling increasing when $\theta > \theta_2$).

As to claim 16, note the rejection of claims 1, 13 above, furthermore the display screen in Bartlett corresponds to the claimed electrical appliance.

As to claims 17, Lee teaches the MEMS sensor is configured to detect movement of the body along or around first and second axes.

As to claims 18, 20, Bartlett teaches generating position signals corresponding to movements of device along first and second directions.

As to claims 54-56, Lee teaches the MEMS sensor is configured to detect movements of the device in a first, second and third directions (page 857, last paragraph in CONCLUSION).

As to claims 57, 58, Fig. 5 of Bartlett teaches the rotation of the body in X (751) and Y (752) and having threshold, thus Bartlett teaches the threshold comprising X axis threshold and Y axis threshold as claimed.

As to claims 63, in addition to the remarks as applied to claim 1, Figs. 2a of Bartlett also discloses determining a rate of change position (changing the angular orientation about an axis of rotation during the time interval).

As to claim 64, Bartlett teaches producing scrolling when $\theta > \theta_1$ (amplitude of change exceeds the amplitude threshold θ_1).

As to claim 65, the highlighted selection band as shown in Figs. 4a and 4b of Bartlett corresponds to a screen pointer, Bartlett also teaches the rate of scrolling increasing when $\theta > \theta_2$.

4. Claims 3, 4, 10, 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett and Lee as applied to claim 1 above, and further in view of Svancarek (US 6,249,274).

As to claims 10, 11, Bartlett further teaches that the control device and the display screen and can separate from each other (e.g. Fig. 7, col. 8 lines 22-27), however Bartlett as modified by Lee does not explicitly disclose the user controlled device having transmission means for connecting the microcontroller to an electrical appliance. Svancarek is cited to teach a user controlled device similar to Bartlett and Lee. Fig. 2 of Svancarek teaches a user controlled device (100) for controlling the computer and microprocessor-based or programmable consumer electronics (electrical appliance) having transmission means (118) for connecting the microcontroller (102) to an electrical appliance (col. 2, lines 25-45), wherein the transmission means comprising a wire or wireless transmission (col. 4, lines 30-31). Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the user input device of Bartlett as modified by Lee to have the transmission means as taught by Svancarek in order to transmit information from microcontroller to computer or electronic device when the display screen is separate from the control device.

As to claim 3, Svancarek teaches the user controlled device comprise support means (134, 136) such that the device is titable around two axes by the user. Thus, it would have been obvious to modify the body of Bartlett as modified by Lee to have support means as claimed for better rotation control.

As to claim 4, Bartlett as modified by Lee and Svancarek does not disclose the body is supported by rounded base, at least one spring, yieldable balls or elastically supported balls. However, it would have been an obvious matter of design choice to modify the body of the user controlled device of Bartlett as modified by Lee and Svancarek to have the limitation as claimed, since such a modification would have involved a mere change in the shape of a components.

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Furthermore, a change in shape of the input device would have been obvious to one having ordinary skill in the art at the time the invention was made, since a mere change in shape or from involves only routine skill in the art. *In re Dailey*, 149 USPQ 47 (CCPA 1976).

5. Claims 5, 6, 35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett and Lee as applied to claims 1 and 30 above, and further in view of Kuga (US 5,701,131).

As to claims 5, 6 and 35, Bartlett as modified by Lee teaches the body is a housing accommodating the MEMs acceleration sensor. Bartlett as modified by Lee does not teach the body is fixed to an article to be worn by a user. However, Figs. 1 and 2 of Kuga teach a user controlled device is fixed to a goggle (4) to be worn by a user. Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the user controlled device of Bartlett as modified by Lee to be fixed to a article and mounted to user's head as taught by Kuga so as to provide a hand free input control device.

6. Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett, Lee and Kuga as applied to claim 6 above, and further in view of Davison (US 4,682,159).

Kuga teaches the article is an eyeglasses. Bartlett as modified by Lee and Kuga does not explicitly disclose the article is a hairband. However, Davison teaches a pointing device is mounted in a hairband. Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the user input device of Bartlett as modified by Lee and Kuga to be mounted to hairband as taught by Davison so as to provide a hand free input control device.

7. Claims 42-45, 48, 50-52 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett in view of Odamura (US 6,765,553).

As to claim 42, Fig. 5 of Bartlett discloses a user controlled device comprising: a body, a sensor (740 Fig. 5) coupled to the body and configured to produce a first signal corresponding to rotation of the body around a first axis (pitch 752), and a circuit configured to produce a movement command (the selection band movement command in the stepwise rate as shown in Figs. 4a and 4b corresponds to the movement command) in a first direction (vertical direction), corresponding to a value of the first signal, when the first signal indicates rotation of the body that is lower than a speed threshold, and to produce a first function command when the first signal indicated rotation of the body that exceeds the speed threshold (note that the gesture command as shown in Figs. 2a-2d correspond to a speed threshold, e.g., in Fig. 2a, the quick movement of the handheld has to be greater than the angular orientation about an axis of rotation during the time interval between T_f - T_s , an activation signal is detected, otherwise, the activation signal is not detected, thus, the angular orientation about an axis of rotation during the time interval reads on a speed of movement threshold or speed threshold as claimed).

Bartlett differs from claim 42 in that the movement command is not a cursor movement command. Odamura is cited to teach a user controlled device similar to Bartlett. Odamura teaches the same movement command can be used to control either a cursor movement command for controlling cursor movement (S24-S26 in Fig. 5, S35-S36 in Fig. 8B) or a scroll movement command for scrolling of display data. Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify movement command of

Bartlett to be a cursor movement command since Odamura teaches the operation of the scrolling data and cursor movement in the user controlled device are equivalent each other and can be controlled by the same position command to simplify operation by the user.

As to claim 43, Bartlett differs from the claimed invention in not disclosing the first function command is a mouse click command. However, Bartlett teaches that a gesture command (e.g. Figs. 2a-2d) is used to perform a selection function and that the gesture command can be in the same direction as the position command (e.g. col. 4 lines 40-41, "Gesture commands can correspond to a pattern of movement relative to one of the three orthogonal axes") and it is old and well known in the art for input devices (e.g. mouse) to provide cursor movement and mouse click command (selection function) by the user (e.g. Bartlett col. 1 lines 39-43). Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the first function command in Bartlett as modified by Odamura to comprise a mouse click function command to allow the user to provide simple cursor movement command and mouse click function command (selection command) to provide for "completely finger-free data input" for an electronic device (Bartlett col. 2 lines 19-22).

As to claim 44, Bartlett discloses the circuit is configured to produce the first function command when the first signal indicates rotation of the body in a first direction exceeding the speed threshold, and to produce a second function command when the first signal indicates rotation of the body in a second direction exceeding the speed threshold (the angular orientation about an axis of rotation during the time interval is reached, and one of gesture command is detected as shown in Fig. 2a).

As to claim 45, note the discussion of claim 43 above. Bartlett as modified by Odamura does not disclose the first function command is a left click command and the second function command is a right click command. However, it is old and well known in the art that a mouse click command comprising a left click command and a right click command. Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the user controlled device Bartlett as modified by Odamura to have a left click command and a right click command so as to provide a conventional mouse clicking functions.

As to claim 48, Bartlett teaches the circuit is configured to produce the movement command only when the first signal indicated rotation of the body exceeding an amplitude threshold (the selection band movement only when the angular orientation $\theta > \theta_1$, see col. 5, lines 42-44).

As to claim 50, Bartlett teaches the thresholds are any preferred value (col. 3, line 63 to col. 4, lines 5), this reads on the speed and amplitude threshold are selectable by user of the device.

As to claim 51, Bartlett teaches the sensor is configured to produce a second signal corresponding to rotation of the body around a second axis (roll 751) perpendicular to the first axis (pitch 752), and the circuit is further configured to produce a second function command when the second signal indicates rotation of the body around the second axis exceeding a respective speed threshold (the angular orientation about an axis of rotation during the time interval is reached, and one of gesture command is detected as shown in Fig. 2a).

As to claim 52, Bartlett teaches it is well known in the art that a user control device can produce a third signal corresponding to movement of the body along a third axis perpendicular to

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the first and second axes, and configured to produce a third command when the third signal indicates movement of the body (col. 2, lines 1-7). Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the device of Bartlett as modified by Odamura to produce the third signal as claimed to optimize the handheld device.

8. Claim 53 is rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett and Odamura as applied to claim 42 above, and further in view of Lee.

Bartlett as modified by Odamura does not disclose the sensor is MEM type sensor. However, Lee teaches a position detection system with MEMS accelerometer. Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the sensor of Bartlett as modified by Odamura to utilize a MEMS acceleration sensor as taught by Lee since the MEMS accelerometer which “gives high sensitivity with low temperature drift” and “the device dimensions optimize large sensitivity over layer area” (see Lee, page 852, lines 2-4 in [2.2]).

Response to Arguments

9. Applicant's arguments filed 2/14/08 have been fully considered but they are not persuasive.

Applicant's remarks regarding Bartlett on pages 21-23 are not persuasive. Applicant's remarks regarding “Bartlett's position command is not generated only if the speed of movement is below a threshold, but are instead generated without consideration of the speed of movement” (page 22, lines 2-3 of the remarks) are not persuasive. As clearly stated in the rejections above,

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Bartlett's device generates the position command signal only when no gesture command is detected and when the tilt amplitude of movement is greater than θ_1 (see col. 5, lines 42-44), which reads on "a microcontroller ...configured to generate first control signals correlated to said positions, only while detected movements of said body are less than a speed of movement threshold and greater than an amplitude of movement threshold" as claimed in claim 1. Bartlett teaches if any of gesture commands are detected (Figs. 2a-2d), the device of Bartlett would generate an activation signal to activate a gesture commands, otherwise, no gesture command is generated, therefore, Bartlett does consider the speed of movement.

Applicant's argument in that "Bartlett does not require that the movement be greater than some value to be seen as a gesture command, but instead requires that the movement be equal to the value, making allowance for minor variations" (page 22, lines 14-17 of the remarks) are not persuasive. Note that Bartlett's teachings is to detect a click function (gesture command – speed of movement threshold) within a position command (scrolling) for activation of a particular selection as in Fig. 4; therefore Figs. 1 and 2a-2d must be viewed together as one. As shown in Fig. 1, a scrolling (position) command is in progress, and in order to detect a click (gesture) command within the scrolling command, an increase in speed of the angular orientation must be detected in the manner as shown in Figs. 2a-2d. As shown in Figs. 2a-2d, the angular orientation of the movement of the device has to be greater than a certain angle (angular orientation as shown in Fig. 1) within a time frame to generate a gesture command. Therefore, Bartlett does require the movement be greater than some value to generate a gesture command and when there is no gesture command the movement of the handheld device is a level which is less than a speed of movement threshold [click command] needed to indicate a position command as claimed.

Applicant's argument in that "claim 1 is not directed to detection of a gesture (or click) command, so whether Bartlett detects a gesture command is not relevant" (page 22, lines 18-19 of the remarks) are not persuasive. Since the claim requires generating position control signal when the detected movement of the body are less than a speed of movement, and Bartlett teaches generating the position command signal when not detecting a gesture command (in another words, the detected movement of the body are less than a speed of movement), therefore, Bartlett does not teaches away from generating first control signal only while detected movement are less than a speed of movement, as recited in claim 1. In Bartlett in order to differentiate between a position command and a gesture (click) command during scrolling, an increase in speed of movement must be detected to indicate a gesture command otherwise the handheld device remains in a position command, therefore contrary to applicant's remarks the detection of a gesture command is relevant. Furthermore, applicant's claim 13 is a gesture command in the same manner as Bartlett and as such the detection of a gesture command is clearly relevant.

Applicant's remarks regarding claims 16, 30, 36, 42, 63 on pages 23-24 are not persuasive, see the rejections and remarks above.

Conclusion

10. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after

the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Regina Liang whose telephone number is (571) 272-7693. The examiner can normally be reached on Monday-Friday from 8AM to 5:00PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Richard Hjerpe, can be reached on (571) 272-7691. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Regina Liang/
Primary Examiner, Art Unit 2629

X. RELATED PROCEEDINGS APPENDIX

None.